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Radian Corp, Austin, TX

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ORGANIC SOLVENT USE STUDY

Final Report

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Final Report

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CONVERSION FACTOR

<u>To convert from</u>	<u>to</u>	<u>Multiply by</u>
pound-mass (lb-mass avoirdupois)	kilogram (kg)	0.454

DISCLAIMER

This report has been reviewed by the Office of Toxic Substances, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

The purpose of this study was to collect readily available information about 34 large volume industrial organic solvents and to present the information in a cohesive, organized manner. The production, consumption, use, exposure and toxicological data collected were used to categorize and rank the solvents in several different ways. Exposure and inhalation toxicity data were analyzed to provide indicators of solvents posing the greatest risk to man and his environment.

From the results of this study, it was concluded that twelve of the solvents considered may present a potential risk. In-depth risk assessment studies were recommended for each of these solvents. Additionally, the study recommended that data on dermal absorption of potentially toxic compounds be found in the literature or generated in the laboratory.

The study also recommended that a pilot program be initiated to assess the utility of extensive manual searches of the open literature for additional solvent information. Additionally, the study recommended that Threshold Limit Values (TLV's) be established for solvents not already assigned TLV's, so that the risk posed by inhalation of these solvents could be more accurately assessed. The study further recommended that assessments of inhalation risk include the effect of vapor pressure.

Each solvent in the study was grouped according to its use. Thirty-nine use categories were developed, based on the Office of Toxic Substances function-application code system. Applicable occupational and consumer exposure potential scores were developed for each category. Tables prepared for each use

category listed the following pertinent information about each solvent in that category: specific solvent uses within the category; non-solvent uses; amount and percent consumed for each solvent and non-solvent use; chemical structural category; inhalation and ingestion toxicity rankings; chemical parent(s); and references.

Because chemicals with similar structures often exhibit similar chemical, physical, and toxicological properties, each solvent in the study was grouped according to its basic chemical structure. Tables prepared for sixteen chemical categories listed specific solvent and non-solvent uses; amount and percent consumed for each use; applicable categories for each solvent use and the exposure potentials developed for each; inhalation and ingestion toxicity; chemical parent(s); and references for each solvent.

Solvents for which quantitative data were available were ranked according to total annual production amounts, total annual consumption amounts, and the amount consumed for solvent use only. Synthetically-produced petrochemical parents of solvents were also ranked according to total annual production.

Solvents for which toxicological data were available were ranked according to their ingestion and inhalation toxicities. Each solvent was also ranked according to its maximum and median occupational and consumer exposure potential score.

Toxicity and exposure potential rankings were prioritized to determine the twelve solvents posing the greatest potential risk.

This report was submitted in fulfillment of Contract No. 68-03-2776, Work Assignment 1, by Radian Corporation under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period from 1 April 1979 to 1 October 1979. Work was completed 1 October 1979.

INTRODUCTION

This document presents the results of a study of 34 large-volume organic chemical solvents. The goal of this project was to collect and present information about the solvents. The information presented will aid OTS in making its assessments of risk provided to man and his environment by these solvents. Use, exposure, toxicological, production, and consumption data were used to categorize and rank the solvents in several different ways. Additionally, an analysis relating exposure to inhalation toxicity was done to provide indicators of solvents within this group posing the greatest risk.

The need for a comprehensive study of chemical solvent use is becoming increasingly apparent, as the potential for exposure in this large class of chemicals is high. The high exposure potential exists not only because of solvents' widespread use, but also because of the methods in which they are used: human exposure is possible through inhalation, direct contact, and even ingestion.

The magnitude of OTS's responsibility in administering the Toxic Substances Control Act (TSCA) with respect to organic solvents is great. Hundreds of solvents, currently used in industrial and consumer applications, fall under the jurisdiction of the Act. And, because the Act covers all points of exposure (manufacturing, processing/commercial use, consumer use, transport, and disposal), OTS's job becomes even larger still.

The information contained in this report will provide OTS with background for developing strategies to determine risks to environmental quality and human health imposed by

solvent manufacture and use. The methodology used in collecting and organizing the information in this study may also be useful to OTS in planning and implementing similar studies on different groups of chemicals.

The number of solvents in current use is too large for their simultaneous study. For this reason, OTS chose to begin its solvent use investigation with a study of 34 large-volume organic solvents. A list of the solvents investigated is shown in Table 1-1. Also shown are the Chemical Abstracts Services (CAS) preferred names and CAS Registry numbers. Synonyms and molecular formulas are included to eliminate confusion over the specific identity of the solvent in question.

The solvents were chosen for study for the following reasons: (1) they were known to be consumed as solvents in relatively large amounts; (2) qualitative data indicated they were used in a variety of solvent applications; (3) qualitative use data indicated that their application was one of high exposure potential; and/or (4) they were known to be highly toxic or suspected carcinogens.

The information presented here resulted from a quick response effort. Information collected during this study was obtained from readily-accessible, easily retrievable sources. Funding and time limitations prohibited in-depth literature searches. A few industry contacts were made, but potential industrial sources of information were not rigorously pursued. This information represents the quantity which could be easily and cheaply obtained, i.e., the point of diminishing returns. Pursuit of further information will require industry participation and/or more intensive searching.

TABLE 1-1. SOLVENTS CHOSEN FOR OTS STUDY

Common Name	Preferred Name and CAS No. ^a	Other Synonyms	Molecular Formula
Acetone	67641 2-propanone	dimethyl ketone; β -keto-propane; dimethylketal; methyl ketone; pyroacetic ether; dimethylformaldehyde	CH_3COCH_3
Amyl acetates	b	acetic acid; pentyl ester; pentyl acetate	
n-butyl alcohol	71363 1-butanol	butyl alcohol; propyl carbinol; n-butanol	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
Carbon disulfide	75150 carbon disulfide	carbon bisulfide	CS_2
Chlorobenzene	108907 benzene, chloro	benzene chloride; chlorbenzol; monochlorobenzene; phenyl chloride	$\text{C}_6\text{H}_5\text{Cl}$
Chloronaphthalene	25586430 naphthalene, chloro-	monochloronaphthalene; halowax	$\text{C}_{10}\text{H}_7\text{Cl}$
Cresols/cresylic acid	1319773 phenol, methyl-	cresylol; tricresol; methylphenol	$\text{HOC}_6\text{H}_4\text{CH}_3$
Cyclohexanone	108941 cyclohexanone	pimelic ketone; ketohexamethylene; pimelin ketone	$\text{C}_6\text{H}_{10}\text{O}$
o-Dichlorobenzene	95501 benzene, 1,2-dichloro	othodichlorobenzene; orthodichlorobenzol; 1,2-dichlorobenzene	$\text{C}_6\text{H}_4\text{Cl}_2$

TABLE 1-1. SOLVENTS CHOSEN FOR OTS STUDY (Continued)

Common Name	Preferred Name and CAS No. ^a	Other Synonyms	Molecular Formula
Diethylene glycol	111466 ethanol, 2,2'-oxybis-	2,2'-oxybisethanol; 2,2'-oxydiethanol; bis(2-ethoxyethyl)ether; diethyl carbitol; glycol ether; glycol ethyl ether	$\text{HOCH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{OH}$
Diethylene glycol monobutyl ether	112345 ethanol, 2-(2-butoxyethoxy)-	butyl carbitol; o-butyl diethylene glycol; diethylene glycol N-butyl ether; diethylene glycol butyl ether; diglycol monobutyl ether; butyl diglycol	$\text{HOCH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{OC}_4\text{H}_9$
N,N-dimethylformamide	68122 formamide, N,N-dimethyl	DMF; dimethylformamide; N-formyldimethylamine	$\text{HCON}(\text{CH}_3)_2$
Dimethylsulfoxide	67685 methane, sulfinylbis-	DMSO; methyl sulfoxide	$(\text{CH}_3)_2\text{SO}$
Ethyl acetate	141786 acetic acid ethyl ester	acetic acidethyl ester; ethyl ethanoate; ethyl acetic ester	$\text{CH}_3\text{COOC}_2\text{H}_5$
Ethylbenzene	100414 benzene, ethyl-	phenylethane; ethylbenzol	$\text{C}_6\text{H}_5\text{C}_2\text{H}_5$
Ethylene glycol monobutyl ether	111762 ethanol, 2-butoxy-	butyl cellosolne; 2-butoxyethanol	$\text{HOCH}_2\text{CH}_2\text{OC}_4\text{H}_9$

TABLE 1-1. SOLVENTS CHOSEN FOR OTS STUDY (Continued)

Common Name	Preferred Name and CAS No. a	Other Synonyms	Molecular Formula
Ethylene glycol monoethyl ether	110805 ethanol, 2-ethoxy-	2-ethoxyethanol; cellosolne; ethyl cellosolne	$\text{HOCH}_2\text{CH}_2\text{OC}_2\text{H}_5$
Ethyl ether	60297 ethane, 1,1'-oxybis-	diethyl ether; ethoxyethane; ethyl oxide; diethyl oxide; anesthetic ether	$\text{C}_2\text{H}_5\text{OC}_2\text{H}_5$
Isobutanol	78831 1-propanol, 2-methyl	2-methyl-1-propanol; isopropylcarbinol; 1-hydroxymethylpropane; isobutyl alcohol; fermentation butyl alcohol	$(\text{CH}_3)_2\text{CHCH}_2\text{OH}$
Methanol	67561 methanol	methyl alcohol; carbinol; wood spirit; wood alcohol	CH_3OH
Methylene chloride	75092 methane, dichloro-	dichloromethane; methylene dichloride; methane dichloride	CH_2Cl_2
Methyl ethyl ketone	78933 2-butanone	2-butanone; ethyl methyl ketone; methyl acetone; MEK	$\text{CH}_3\text{COCH}_2\text{CH}_3$
Methyl isobutyl ketone	108101 2-pentanone, 4-methyl-	isopropylacetone; 4-methyl-2- pentanone; MIBK; isobutyl methyl ketone; MIK; 2-methyl-4- pentanone	$\text{CH}_3\text{COCH}_2\text{CH}(\text{CH}_3)_2$
Nitrobenzene	98953 benzene, nitro-	nitrobenzol; C.I. Solvent Black 5	$\text{C}_6\text{H}_5\text{NO}_2$

TABLE 1-1. SOLVENTS CHOSEN FOR OTS STUDY (Continued)

Common Name	Preferred Name and CAS No. ^a	Other Synonyms	Molecular Formula
Perchloroethylene	127184 ethene, tetrachloro	tetrachloroethylene; ethylene tetrachloride; tetrachloroethene; perc; carbon dichloride	C_2Cl_4
Pyridine	110861 pyridine	azabenzene; azine	C_5H_5N
Toluene	108883 benzene, methyl-	methylbenzene; toluol; phenylmethane; methylbenzol	$C_6H_5CH_3$
Trichloroethane	79005 ethane, 1,1,2-trichloro-	1,1,2-trichloroethane; vinyl trichloride; ethane trichloride; 1,2,2-trichloroethane	$CH_2ClCHCl_2$
Trichloroethylene	79016 ethene, trichloro-	trichloroethene; 1-chloro- 2,2-dichloroethylene; 1,1,2-trichloroethylene; 1,2,2-trichloroethylene; ethylene trichloride	CCl_2CHCl
Trichlorofluoromethane	75694 methane, trichlorofluoro	trichloromonofluoromethane; fluorotrichloromethane; Freon 11	CCl_2F
Triethylene glycol	112276 ethanol, 2,2'- [1,2-ethanediy]bis (oxy)]bis-	2,2'-ethylenedioxydiethanol; glycol bis (hydroxyethyl) ether TEG; Triglycol	$HO(C_2H_4O)_3H$

TABLE 1-1. SOLVENTS CHOSEN FOR OTS STUDY (Continued)

Common Name	Preferred Name and CAS No. ^a	Other Synonyms	Molecular Formula
1,1,2-trichloro-1,2,2-trifluoroethane	76131 ethane, 1,1,2-trichloro-1,2,2-trifluoro-	trichlorotrifluoroethane; Freon 113; 1,1,2-trifluoro-1,2,2-trichloroethane; 1,2,2-trichlorotrifluoroethane;	CCl ₂ FCF ₂
Xylenes	1330207 benzene, dimethyl	dimethylbenzene, Xylol	C ₆ H ₄ (CH ₃) ₂

^aAs listed in the Toxic Substances Control Act Chemical Substance Inventory.

^bNo CAS number was found for the mixed stream of Amylacetates.

The remainder of this report contains the information collected about each solvent, which has been categorized in a number of different ways. The kinds of information include specific solvent and non-solvent uses, annual production and consumption quantities, toxicity information, basic chemical structure, and occupational and consumer exposure potential. Section 2.0 contains conclusions and recommendations which resulted from analysis of the information collected.

Section 3.0 contains a series of tables in which information about each solvent is grouped according to solvent use. The tables in Section 4.0 group the solvents and the information describing each into categories based on chemical structure.

In Section 5.0, the solvents are ranked in several ways: total annual production, total annual consumption, and amount consumed in solvent uses. Chemical parents of the solvents studied are also listed and ranked by total annual production. Methods for determining exposure potential and toxicity are discussed in this section, and solvents are ranked in each of these categories.

Section 6.0 compares toxicity and exposure rankings. The methods are described by which composite risk scores were obtained, and the solvents which appear to present the greatest consumer and occupational risks are listed. Complete references are cited in Section 7.0.

Appendix A contains a detailed description of Auerbach Associates' methodology in developing the EPA Index of Exposure. Exposure Index Scores developed with Auerbach's model are included in Appendix B. Appendix C includes the

results of a manual patent search performed for five solvents: acetone, diethylene glycol, ethylene glycol monobutyl ether, ethylene glycol monoethyl ether, and xylenes. The uses found in the patent literature are presented in the Appendix because the commercial significance could not be ascertained.

CONCLUSIONS, RECOMMENDATIONS, AND RESULTS

Recommendation: In-depth risk assessment studies should be undertaken for each of the twelve high risk solvents.

One of the major conclusions reached in this study is that twelve of the solvents considered may have potential for presenting risk to man and his environment. These solvents are listed in Table 2-1. Indicators derived through screening, ranking, and analytical methods show that further study is warranted for these solvents.

TABLE 2-1. POTENTIAL HIGH-RISK SOLVENTS

Nitrobenzene
N,N-Dimethylformamide
n-Butyl alcohol
Cyclohexanone
o-Dichlorobenzene
Ethylene glycol monobutyl ether
Isobutanol
Xylenes
Ethyl benzene ^a
Chlorobenzene
Methyl isobutyl ketone
Cresols/Cresylic acid

^aA component of mixed Xylenes.

Recommendation: To assess the utility of extensive manual searches of the open literature, a pilot study should be initiated in which an intensive manual search is performed for a small group of solvents.

Gaps in information were identified for several of the solvents. The list of solvents was chosen for the most part from those which were well characterized in easily accessible sources. Areas of missing information for each solvent are shown in Table 2-2. In order to completely assess the risk posed by the solvents in this study, important missing information must be obtained. Also, to proceed with further studies of solvent use and the risk presented, consideration must be given to augmenting information sources.

Recommendation: Threshold Limit Values (TLV's) should be established in the very near future for those solvents which had not been assigned TLV's. Analysis of risk posed by these solvents can then be completed.

Recommendation: Data on dermal chemical absorption rates should be found through intensive searches or generated in the laboratory. Risk provided through topical exposure of these chemicals can then be completed.

The toxicity ranking work indicates that the important routes of exposure are topical and inhalation. Unfortunately, TLV's were not available for some of the solvents considered in this study. This precluded their inclusion in the rankings. Furthermore, there is such a paucity of data for dermal toxicity that rankings could not be attempted.

Recommendation: An assessment of risk posed by solvents through inhalation should take vapor pressure into consideration.

Although a number of solvents had low inhalation toxicity rankings, their vapor pressures were high. This indicates that dosages may also be high.

TABLE 2-2. CHEMICALS FOR WHICH INFORMATION
WAS NOT READILY AVAILABLE

Chemical Name	Area(s) of Missing Information
N,N-Dimethylformamide	Total Annual Production Total Annual Consumption Total Annual Consumption as Solvent
Chloronaphthalenes	Total Annual Production Total Annual Consumption Total Annual Consumption as Solvent Toxicity via Inhalation
Dimethyl sulfoxide	Total Annual Production Total Annual Consumption Total Annual Production of Chemical Parent
Amyl acetates	Total Annual Consumption Total Annual Consumption as Solvent Total Annual Production of Chemical Parent Toxicity via Ingestion
o-Dichlorobenzene	Total Annual Consumption Total Annual Consumption as Solvent
Diethylene glycol	Toxicity via Inhalation
Diethylene glycol monobutyl ether	Toxicity via Inhalation
Triethylene glycol	Toxicity via Inhalation

Summary of Results

The results of the various rankings and categorizations of solvents are presented in Sections 3.0, 4.0, and 5.0 of this report. An analysis comparing toxicity and exposure potentials is included in Section 6.0. Highlights or summaries of the results of the ranking, categorization, and analytical work are presented here. Details are included in the body of the report.

Ranking of Solvents by Production Volume

The three solvents considered for this study having the largest U.S. production volumes are listed below. Volumes cited total annual production which includes solvent and non-solvent uses.

Toluene	7730 MM lb
Ethyl benzene	7300 MM lb
Methanol	6460 MM lb

Ranking of Solvents by Total Domestic Consumption Volume

Of the list of solvents considered, the following three had the largest domestic consumption volumes in solvent and non-solvent uses.

Methanol	7000 MM lb
Toluene	6770 MM lb
Xylenes	5810 MM lb

Ranking of Solvents by Total Domestic Solvent Consumption

The three solvents which have the largest consumption volumes as solvents are:

Xylenes	1080 MM lb
Methanol	700 MM lb
Toluene	700 MM lb

Ranking by Volume of Production of Chemical Parents

Of the chemical parents of the solvents studied, the following have the highest production volumes.

Ethylene	24,650 MM lb
Propylene	12,560 MM lb
Benzene	11,250 MM lb

Ranking by Toxicity

The following solvents had the highest toxicities with respect to inhalation and ingestion exposure.

<u>Inhalation</u>	<u>Ingestion</u>
Nitrobenzene	o-Dichlorobenzene
Cresols/cresylic acid	Nitrobenzene
Pyridine	n-butyl alcohol

Ranking by Consumer Exposure

The solvents having the highest index of exposure scores using maximum and median values are listed below.

Maximum
Ethyl benzene^a
Xylenes

Median
Ethyl benzene^a
Chlorobenzene

Ranking by Occupational Exposure

Solvents having the highest occupational exposure scores using maximum and median values are those listed here.

Maximum
Ethylbenzene^a
Xylenes
Methyl isobutyl ketone
Chlorobenzene
1,1,1-trichloroethane

Median
Chlorobenzene
Trichlorofluoromethane

Categorization by Use

In the grouping of solvents in their various uses, it was found that the largest number are used in paint and allied products. The category having the second highest number of chemicals is repair work.

Categorization by Chemical Structure

There were no dominant chemical groups in the list of solvents. The various solvents were fairly evenly distributed among the different chemical structure categories.

^aA component of mixed Xylenes.

Comparison of Toxicity and Exposure to Consumers

The following list of chemical solvents ranked high in the analysis of toxicity vs. exposure to consumers.

Nitrobenzene
N,N-Dimethylformamide
n-Butyl alcohol
Cyclohexanone
o-Dichlorobenzene
Ethylene glycol monobutyl ether
Isobutanol
Ethylbenzene
Methyl isobutyl ketone
Xylenes

Comparison of Toxicity and Occupational Exposure

The following list of solvents ranked high in the analysis of toxicity vs. occupational exposure.

N,N-Dimethylformamide
Cyclohexanone
o-Dichlorobenzene
Ethylene glycol monoethyl ether
Chlorobenzene
Ethyl benzene
Methyl isobutyl ketone
Xylenes
Cresols
Isobutanol

The diversity of solvent uses for the chemicals in this study made it necessary to develop use categories into which similar specific uses could be grouped. The function-application chemical use classification system developed by OTS was utilized as a basis for the use categories for a number of reasons: (1) the functions and applications are uniformly coded and indexed; (2) the function-application codes are flexible and may be applied in a number of combinations; and (3) the use categorization system was linked with the EPA Index of Exposure. The EPA Index of Exposure is a model developed by Auerback Associates for EPA. The model estimates the intensity of exposure to humans and the environment resulting from specific chemical applications. Further information on the model is presented in Section 5.0 and in Appendix A.

This model was used in this study to estimate solvent exposure potentials. Whenever possible, use categories developed for the EPA Index of Exposure were used to group the solvents. However, in a number of cases, these categories were inappropriate, either because the uses they encompassed were not clearly defined, or because they did not include particular types of solvent use. In these situations, Radian used the OTS classification system to develop appropriate use categories which are compatible with the system.

A total of 38 solvent use categories were developed. Table 3-1 lists the categories and the number of chemicals included in each. Since many of the chemicals studied could be used in several discrete solvent applications, most of the chemicals appeared under more than one category.

The tables which follow were prepared for each solvent use category. In addition to listing both occupational and consumer exposure potentials, the table for each category included the following information about the solvent in the category:

- Chemical name
- Specific solvent uses within the category
- Non-solvent uses
- Consumption quantities for solvent and non-solvent uses
- Percentages of total consumption applicable to each use
- Chemical structural category
- Primary chemical parents.

The number in parentheses after each table title refers to the OTS function and application chemical use classification system from which the category was derived.

TABLE 3-1. SOLVENT USE CATEGORIES

Name of Category	OTS Use Code No.	Number of Solvents Within Category
Solvents for Adhesives	352-I009	9
Solvents for Chemicals	352-02	13
Solvents for Research and Development	352-0406	4
Solvents for Laundry and Drycleaning	352-0412	4
Solvents for Repair Work	352-042	13
Solvents for Furniture Repair and Refinishing	352-0421	7
Solvents for Fabricated Rubber and Plastic Products	352-07	3
Solvents for Oil and Gas Extraction	352-154	1
Solvents for Paint and Allied Products	352-18	19
Solvents for Petroleum Refining	352-20	5
Solvents for Plastic and Rubber Materials (not fabricated)	352-21	9
Solvents for Printing Operations	352-231	15
Solvents for Printing Inks	352-24	14
Solvents for Polishes and Related Products	352-2511	3
Solvents for Surface Cleaning and Conditioning	352-0645	11

TABLE 3-1. SOLVENT USE CATEGORIES (Continued)

Name of Category	OTS Use Code No.	Number of Solvents Within Category
Solvents for Plain-dyed Yarn, Finished Fibers, and Fabrics ^a	352-11330-2702	2
Solvents for Manufacturing ^a Dyes	352-11330	4
Tar Removers for Laundry and Drycleaning	366-0412	2
Tar Removers for Cleaning and Maintenance	366-0400	2
Solvents for Wool Cleaning ^a	352-0006	1
Solvents for Drain Cleaners ^a	352-25126	1
Solvents for Manicuring Preparations ^a	352-2504	1
Solvents for Fluorescent Lamps ^a	352-14110	1
Solvents for Shoe Polishes ^a	352-25115	1
Solvents for Aerosol Personal Products ^a	352-000c ^b	1
Solvents for Capacitors ^a	352-000e ^b	1
Solvents for Chemicals for Brazing, Welding and Soldering ^a	352-12274-0640	1
Solvents for Spotting Agents ^a	352-1309-04120	4
Solvents for Specialty Lubricants ^a	352-1271	1
Solvents for Food ^a	352-000a ^b	2

TABLE 3-1. SOLVENT USE CATEGORIES (Continued)

Name of Category	OTS Use Code No.	Number of Solvents Within Category
Solvents for Crop Production ^a	352-012	2
Solvents for Paper Coatings ^a	352-I132-19	7
Solvents for Pesticides ^a	352-I299	6
Solvents for Hydraulic Fluids for Transportation Equipment ^a	352-I252-28	3
Solvents for Roll Coatings ^a	352-000f ^b	13
Solvents for Pharmaceuticals ^a	352-000 ^b	16
Solvents for Explosives ^a	352-I206 or 352-170	3
Solvents for Coating Magnetic Wire	352-I2601-1461	2
Solvents for Textile Processing	352-I363	4

^aFor these categories Radian derived exposure indices and OTS use codes using the method of Auerbach Associates.

^bFor these categories Radian was unable to derive use code numbers.

TABLE 3-2. SOLVENT FOR DYES FOR PLAIN DYED AND FINISHED FIBERS, YARN AND FABRICS^a

OTS Use Code No: 352-11330-2702

EXPOSURE POTENTIAL: Occupational: 3.08

Consumer: 1.42

Solvent Name	% Total Consumption	Annual Consumption (MT 10/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking: Inhalation	Toxicity Ranking: Ingestion	Chemical Parent(s)	References
N,N-Dimethyl formamide	NA	NA	Gasoline additive, Organic synthetics, Quench for hot-dip tinned articles, Carboxylation rxn, catalyst		Amide	4	13	Dimethylamine Methyl formate	5, 22, 29
Diethylene glycol monobutyl ether	25%	3		Solvent in liquid dyes					
	33%	5		Coalescing agent in latex paints	Ether	NA	21	Ethylene glycol butanol	29
	42%	<7	Chemical intermediate for diethylene glycol monobutyl ether acetate						
				Solvent in liquid dye baths					

NA - Not Available

^aRadian derived

^bOnly solvent uses within this use category are listed.

TABLE 3-3. SOLVENTS FOR MANUFACTURING DYES^a

OTS Use Code No: 352-11330

EXPOSURE POTENTIAL: Occupational: 2.24

Consumer: Not applicable

Solvent Name	Σ Total Consumption	Annual Consumption (98-11/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Ethyl benzene	96Z	5540	Synthesis of styrene		Aromatic	12	17	Benzene	21
	2Z	140	Export					Xylene	
	< 2Z	12		Solvent for dyes				Ethylene	
Methanol	4Z	300	Acetic acid mfg.		Alcohol	19	24	Methane	21, 24, 36
	10Z	700	1987 mfg.					Synthetic gas	
	45Z	3100	Formaldehyde mfg.						
	4Z	300	Methyl halides						
	8Z	600	Methyl methacrylates						
	4Z	300	Methylamines						
	15Z	1000	Miscellaneous uses (including glycol methyl ethers & formaldehyde inhibitor)						
Xylenes	<10Z	NA	Production of ethyl benzene	Solvent for dyes	Aromatic	12	NA	Petroleum and coal tar isolate	5, 29
	6Z	363	Individual isomers						
	66Z	3993	Guaiacol pool & miscellaneous						
	10Z	605							
	< 9Z	< 544		Solvent for dyes					
n, n-Dimethylformamide	NA	NA	Organic synthesis in Enso line additive		Amide	4	13	Dimethylamine	5, 22, 29
			Quench for hot-dip tinned articles					Acetyl formate	
			Cathodization rxn. catalyst						
	NA	NA		Solvent for mfg. dyes					

NA = Not Available

^aRadion derived^bOnly solvent uses within this use category are listed.

TABLE 3-4. SOLVENT FOR PLASTICS AND RUBBER MATERIALS AND SYNTHETICS (not fabricated)

OTS Use Code No: 352-21

EXPOSURE POTENTIAL: Occupational: 1.90

Consumer: Not applicable

Solvent Name	2. Total Consumption	Annual Consumption (000 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent (s)	References
Acetone	NA	90	Bisphenol A		Ketone	25	22	Isopropanol	5, 23
	NA	48	Diacetone alcohol					Cumene	
	NA	50	Hexylene glycol						
	NA	35	Isophorone						
	NA	27	Mesityl oxide						
	NA	100	Methacrylic acid						
			& higher methacrylates						
	NA	44	Methyl isobutyl carbinol						
	NA	263	Methyl isobutyl ketone						
	NA	476	Methyl methacrylate						
	NA	115	Pharmaceuticals						
	NA	NA	Dicalcium phosphate						
	NA	80							
				Cellulose acetate spinning solvent					
Cyclohexanone	402	300	Caprolactam		Ketone	6	9	Cyclohexane	22, 29
	552	380	Adipic acid					Phenol	
	< 52	< 20							
				Solvent for crude rubber					
Methyl isobutyl Ketone	112	21	Export		Ketone	12	11	Acetone	14, 24, 34
Ethyl acetate	32	6	Chemical synthesis		Ester	23	23	Acetic acid	21, 23, 29
	107	20						Ethanol	
				Solvent for plastics					
Methylene chloride	192	150	Vapor pressure dependent solvent for plastics processing		Non-cyclic halogenated alkane	19	5	Methane	29, 35
	122	86						Ethanol	
	NA	NA		Solvent in mfg. synthetic fibers					

TABLE 3-4. SOLVENT FOR PLASTICS AND RUBBER MATERIALS AND SYNTHETICS (Continued)

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses*	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Formula	References
N,N-Dimethyl-formamide	NA	NA	Gasoline additive organic synthesis quench for hot-dip tinned articles carbonylation rxn. catalyst		Amide	4	13	Dimethylamine N-ethyl formate	5, 22, 29
	NA	NA		Solvent for polar polymers (esp. polyamides)					
	NA	NA		Solvent for synthetic fibers (particularly acrylics, modacrylics, and polyurethane)					
Percyloxyethyl-one	122	80	Chemical intermediate for fluorocarbons 113, 114, 115, 116		Non-cyclic halogenated alkene	12	NA	Ethylene dichloride Paraffins	35, 36, 38
	12	20	Other applications - heat exchanger fluid; pharmaceuticals						
	NA	NA		Solvent for silicones					
Chloronaphthalenes	NA	NA	Varnishes, resins and gums Water, flame-, insecticide, acid-proofing of firebricks Condenser impregnation Heat transfer medium Plasticizers Waxes and flame-proofing covered wire and cable		Polynuclear aromatic	NA	8	Naphthalene	13, 41
	NA	NA		Solvent for synthetic fiber and film					

TABLE 3-4. SOLVENT FOR PLASTICS AND RUBBER MATERIALS AND SYNTHETICS (Continued)

Solvent Name	Total Consumption (100 lb/yr)	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent(s)	References
Dimethyl sulfide	NA	NA		Solvent in alg. polymers	Sulfonide	NA	20	Dimethyl sulfide	8, 19, 41

NA = Not Available

^a Only solvent uses within this category are listed.

TABLE 3-5. TAR REMOVERS FOR LAUNDRY AND DRYCLEANING

OTS Use Code No: 366-0412

EXPOSURE POTENTIAL: Occupational: 3.16

Consumer: Not applicable

Solvent Name	g Total Consumption	Annual Consumption (lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Patent (s)	References
Chloroacetaldehyde	NA	NA	Varnishes, resins and gums	Polynuclear aromatic	NA	8	13, 41		
	NA	NA	Water-, flame-, insect-, and acid-proofing of fibrous bodies						
	NA	NA	Condenser impregnation						
	NA	NA	Heat transfer medium						
	NA	NA	Plasticizers						
	NA	NA	Moisture- and flame-proofing covered wire and cable						
	NA	NA							
	NA	NA							
	NA	NA							
	NA	NA							
N,N-Dimethyl-formamide	NA	NA	Gasoline additive	Amide	4	13	5, 22, 29	Dimethylamine Sethyl formate	
	NA	NA	Organic syntheses						
	NA	NA	Quench for hot-dip tinne articles						
	NA	NA	Carboxylation rxn. catalyst						
	NA	NA	Cleaning solutions for carbonaceous and greasy deposits						

NA = Not Available

^a Only solvent uses within this category are listed.

TABLE 3-6. SOLVENTS FOR LAUNDRY AND DRYCLEANING

OTS Use Code No: 352-0412

EXPOSURE POTENTIAL: Occupational: 2.41

Consumer: (In coin operated laundries): 2.08

Solvent Name	% Total Consumption	Annual Consumption (lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Acetyl acetate	NA	NA	Textile printing and finishing		Ester	12	NA	Acetyl acetate	22, 24
Perchloroethylene	122	80	Chemical intermediate for fluorocarbons 113, 114, 115, 116	Solvent for dry cleaning preparations	Non-cyclic halogenated alkane	12	NA	Ethylene dichloride Paraffins	35, 36, 38
1,1,2-Trichloro-1,2,2-trifluoroethane	<22.4	<15	Atmospheric refrigerants Flowing agent Polymer intermediate Solvents of chlorinated hydrocarbons	Dry cleaning solvent	Non-cyclic halogenated alkane	25	NA	Perchloroethylene	9, 20
Trichloroethylene	62	25	Chain terminator for polymerization of polyvinyl chloride Anesthetic heat transfer medium	Dry cleaning solvent	Non-cyclic halogenated alkane	12	18	Ethylene dichloride Acetylene	21, 29, 35
	<42	<15		Solvent for cleaning textiles and wool					

NA = Not Available

Only solvent uses within this category are listed.

OTS Use Code No: 352-00b^b
 TABLE 3-7. SOLVENTS FOR WOOL CLEANING^a
 EXPOSURE POTENTIAL: Occupational: 3.08
 Consumer: Not applicable

Solvent Name	g Total Consumption	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking Initial score	Toxicity Ranking Adjusted score	Chemical Parent(s)	References
Trichloroethylene	62	25	Chain terminator for polymerization of polyvinyl chloride Adhesives Aesthetics Heat transfer medium	Solvent for cleaning textiles and wool	Non cyclic halogenated alkene	12	18	Etchane dichloride Acetylene	21, 29, 35
NA	NA	NA							
NA	NA	NA							
< 42	< 15								

NA - Not Available

^aRadon derived

^bRadon was unable to derive a use code number for this category.
^cOnly solvent uses within this category are listed.

TABLE 3-8. SOLVENTS FOR CHEMICALS

OTS Use Code No: 352-02

EXPOSURE POTENTIAL: Occupational: 2.24

Consumer: Not applicable

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Acetone	NA	90	Displacement		Ketone	25	22	Isopropanol Cumene	5, 23
	NA	48	Diacetone alcohol						
	NA	50	Hexylene glycol						
	NA	35	Isophorone						
	NA	27	Resinyl oxide						
	NA	100	Reductive acid and higher methacrylates						
	NA	44	Hexyl isobutyl ketone						
	NA	264	Hexyl isobutyl ketone						
	NA	476	Hexyl methacrylate						
	NA	115	Pharmaceuticals						
	NA	NA	Diaceticum phosphate						
	NA	305	Miscellaneous						
	NA	100		Chemical processing solvent					
Amyl acetates	NA	NA	Textile printing and finishing		Ester	12	NA	Amyl alcohols Acetic acid	22, 24
	NA	NA		Wax remover solvent for photographic film					
Triethylene glycol	122	19	Humectant		Glycol	NA	27	Ethylene glycol Ethylene oxide	29
	302	30	Saturated gas dehydration and polymerization						
	82	9	Polyester and polyurethane resins						
	122	13	Vinyl plasticizer						
	62	6	Export						
	NA	NA		Chemical reaction solvent					

TABLE 3-8. SOLVENTS FOR CHEMICALS (Continued)

Solvent Name	% Total Consumption	Annual Consumption (984 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent(s)	References
Carbon disulfide	39%	310	Intermediate in rayon mfg. Intermediate in carbon tetrachloride mfg. Cellulose mfg. Other chemical production		Thione	5	NA	Methane	29
	25%	200							
	14%	110							
	NA	NA							
	<2%	<170							
o-Dichlorobenzene	6%	36	Mfg. 3,4-dichloro-aniline & other pesticides Mfg. other dyes Miscellaneous uses	Solvent for waxes, oils, sulfur and sulfur compounds	Halogenated aromatic	6	1	Benzene	10, 18
	5%	3							
	5%	3							
	1%	8							
Dimethyl sulfoxide	NA	NA		Process solvent for toluene dithiocyanate					
	NA	NA		Solvent for aromatics and heterocyclics Solvent for high molecular weight compounds	Sulfonide	NA	20	Dimethyl sulfide	9, 19, 41
Methanol	4%	300	Acetic acid mfg. DME mfg. Formaldehyde mfg. Methyl halides Methyl methacrylates		Alcohol	19	24	Methane Synthesis gas	21, 24, 34
	10%	700							
	4%	3100							
	4%	300							
	8%	600							
	4%	300							
	1%	1000							
	<10%	115		Solvent for windshield washing preparations Chemical process solvent (includes 20 MM lb for Nylon 66 production					
		700							

TABLE 3-8. SOLVENTS FOR CHEMICALS (Continued)

Solvent Name	Σ Total Consumption (1000 lb/yr)	Annual Consumption (1000 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Methyl isobutyl ketone	112 ≤102	21 ≤ 18	Export Chemical processing Solvent for mineral oils and waxes Solvent for acrylic- nitrile cements Solvent for butadiene Solvent in metal extraction		Ketone	12	11	Acetone	14, 24, 34
Nitrobenzene	972	650	Synthesis of aniline		Nitrated Aromatic	1	2	Benzene	12, 21
N,N-Diacetylformamide	NA	NA	Gasoline additive Organic synthesis Quench for hot-dip tinned articles Carboxylation ran. catalyst	Solvent in chlorina- tion reactions Solvent in allyla- tion reactions	Amide	4	11	Dimethylamine Methyl formate	5, 22, 29
Methyl ethyl ketone	62 ≤ 62	30 ≤ 30	Miscellaneous	Solvent for butadiene and acid gases; acetylene	Ketone	19	16	sec-Butyl alcohol Butane	21, 24
Chloronaphthalenes	NA	NA	Varnishes, gums, resins Water-, flame-, insect- and acid-proofing of fibrous bodies Condenser impreg- nation Heat transfer medium Plasticizers Moisture and flame- proofing of covered wire and cable	Extractive solvent in aq. TPA	Polynuclear Aromatic	8K	8	Naphthalene	13, 41
	NA	NA		Solvent for aniline, other dyestuffs, mineral and vege- table oils					

TABLE 3-8. SOLVENTS FOR CHEMICALS (Continued)

Solvent Name	X Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Patent (%)	References
						Inhalation	Ingestion		
Ethyl ether	25%	45	Chemical synthesis (including chlorination)		Ether	23	10	Ethylene	5, 22, 29
	32%	5	Medical uses (including anesthesia)						
	7%	10	Misc. uses (including detergent for alcohol and refrigerant)						
	NA	NA		Extractive solvent for fats, oils, waxes					
	NA	NA		Extraction & concentration of acetic acid					

NA - Not Available

^a Only solvent uses within this category are listed.

TABLE 3-9. SOLVENT FOR DRAIN CLEANERS^a

OTS Use Code No: 352-25126

EXPOSURE POTENTIAL: Occupational: 1.90

Consumer: 2.91

Solvent Name	Σ Total Consumption	Annual Consumption (ppm 10/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Percent (%)	References
1,1,1-Trichloroethane			Chemical intermediates for vinylidene chloride	Solvent in drain cleaners	Non-cyclic halogenated alkane	22	25	Ethane Ethylene dichloride	5, 29, 35

^aRadion derived^bOnly solvent uses within this category are listed.

TABLE 3-10. SOLVENTS FOR MANICURING PREPARATIONS^a

OTS Use Code No: 352-2504

EXPOSURE POTENTIAL: Occupational (mfr.): 1.57; Occupational (manicurists): 2.74

Consumer: 2.66

Solvent Name	Total Consumption	Actual Consumption (ppm 10/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking Initialation	Toxicity Ranking Repetition	Chemical Percent (%)	References
Amyl acetates	NA	NA	Textile printing and finishing	Solvent in the production of nail polish	Ester	12	NA	Amyl alcohol, Acetic acid	22, 24

NA - Not Available

^aRadon derived

^bOnly solvent uses within this category are listed.

TABLE 3-11. SOLVENT FOR FLUORESCENT LAMPS^a

OTS Use Code No: 352-14110

EXPOSURE POTENTIAL: Occupational: 1.90

Consumer: Not applicable

Solvent Name	2 Total Consumption	Annual Consumption (M T/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent(s)	Boiling Point
Acetyl acetate			Textile printing and finishing	Phosphor solvent in fluorescent lamps	Ester	12	14A	Acetyl alcohol Acetic acid	22, 24

NA - Not Available

^aRadical derived^bOnly solvent uses within this category are listed.

TABLE 3-12. SOLVENTS FOR OIL AND GAS EXTRACTION

OTS Use Code No: 352-154

EXPOSURE POTENTIAL: Occupational: 1.82

Consumer: Not applicable

Solvent Name	Σ Total Consumption	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Diethylene glycol	72	20	Natural gas dehydration		Glycol	NA	26	Ethylene oxide	22, 29
	72	20	Plastics & surfactants						
	302	95	Polyurethane and unsaturated polyester						
	122	38	Textile agents						
	132	41	Triethylene glycol						
	242	57	Manufacture of ethylene glycol (including exports)						
	72	20		Petroleum extraction solvent					

NA - Not Available

^aOnly solvent uses within this category are listed.

TABLE 3-13. SOLVENTS FOR SHOE POLISHES^a

OTS Use Code No: 352-25115

EXPOSURE POTENTIAL: Occupational: 1.90

Consumer: 2.57

Solvent Name	2 Total Consumption	Annual Consumption (99 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Formula	References
1,1,1-Trichloroethane	233	120	Chemical intermediates for vinylidene chloride	Solvent in shoe polishes	Non-cyclic halogenated alkane	22	25	Ethane trichloro dichloride	5, 29, 35
	NA	NA							

NA - Not Available

^aRadium derived^bOnly solvent uses within this category are listed.

TABLE 3-14. SOLVENTS FOR AEROSOL PERSONAL PRODUCTS^a

OTS Use Code No: 352-00^b

EXPOSURE POTENTIAL: Occupational: 2.24

Consumer: 2.58

Solvent Name	Σ Total Consumption	Annual Consumption (lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking		Chemical Parent (s)	References
						Inhalation	Ingestion		
1,1,1-Trichloro-ethane	25%	120	Chemical intermediate for vinylidene chloride		Non-cyclic halogenated alkane	22	25	Ethane Ethylene dichloride	5, 29, 35
	< 6%	< 30		Solvent for active ingredients in aerosols (including deodorants, antiperspirants)					

^aRadon derived

^bRadon was unable to derive a use code number for this category.

^cOnly solvent uses within this category are listed.

TABLE 3-15. SOLVENTS FOR FABRICATED RUBBER AND PLASTIC PRODUCTS

OTS Use Code No: 352-07

EXPOSURE POTENTIAL: Occupational: 3.00

Consumer: Not applicable

Solvent Name	Annual Consumption (lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Exposure	References
					Inhalation	Ingestion		
Methylene chloride	192	Vapor pressure depressant in aerosol spray	Solvent in afg. synthetic fibers	Non-cyclic halogenated alkane	19	5	Methane Methanol	29, 35
1,1,2-Trichloro-1,2,2-trifluoroethane	NA	Aerosols Refrigerants Blowing agent Polymer intermediate Synthesis of chloro-trifluoroethylene	Solvent for magnetic tape Solvent for photographic film	Non-cyclic halogenated alkane	25	NA	Perchloroethylene	9, 20
	<22.4							
	< 15							
Amyl acetates	NA	Textile printing & finishing	Solvent for photographic film	Ester	12	NA	Acetic acid Amyl alcohols	22, 24
	NA		Solvent for photographic film					
	NA		Solvent for production of artificial leather					

NA - Not available

^a Only solvent uses within this category are listed.

TABLE 3-16. SOLVENTS FOR CAPACITORS^aOTS Use Code No: 352-000e^b

EXPOSURE POTENTIAL: Occupational: 1.90

Consumer: Not applicable

Solvent Name	Σ Total Consumption	Annual Consumption (PM lb/yr)	Non Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent (s)	References
N,N Dimethyl-formamide	NA	NA	Gasoline additive for anti-icing organic synthesis (primarily aldehydes) Quench for hot-dip tinned articles Carboxylation rxn. catalyst		Amide	4	11	N,N Dimethyl formamide	3, 22, 29
	NA	NA		Electrolyte solvent in high voltage capacitors					

NA - Not Available

^aKadian derived^bKadian was unable to derive a use code number for this category.^cOnly solvent uses within this category are listed.

TABLE 3-17. SOLVENTS FOR CHEMICALS FOR BRAZING, WELDING AND SOLDERING^a

OTS Use Code No: 352-12274-0640

EXPOSURE POTENTIAL: Occupational: 1.75

Consumer: Not applicable

Solvent Name	Total Consumption	Annual Consumption (lb/yr)	Non-Solvent Uses	Specific Solvent Usage	Chemical Structural Category	Toxicity Ranking		Chemical Percent(s)	References
						Inhalation	Ingestion		
Acetone	NA	90	Bisphenol A		Ketone	25	22	Isopropanol Cumene	3, 21
NA	48	48	Diacetone alcohol						
NA	50	50	Hexylene glycol						
NA	35	35	Isophorone						
NA	27	27	Methyl oxide						
NA	100	100	Metacrylic acid and higher methacrylates						
NA	44	44	Methyl isobutyl carbitol						
NA	263	263	Methyl isobutyl ketone						
NA	476	476	Methyl methacrylate						
NA	115	115	Pharmaceuticals						
NA	NA	NA	Dicalcium phosphate						
NA	305	305	Miscellaneous						
NA	10	10		Solvent for acetylene absorbance in cylinders					

NA - Not Available

^aRadlan derived^bOnly solvent uses within this category are listed.

TABLE 3-18. SOLVENTS FOR SPOTTING AGENTS^a

OTS Use Code No: 352-1309-04120

EXPOSURE POTENTIAL: Occupational: 2.74

Consumer: 2.74

Solvent Name	Σ Total Consumption	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Cyclohexanone	402 554 NA	300 300 NA	Caprolactam Adipic acid	Spot remover for leather & textiles	Ketone	6	9	Cyclohexane Phenol	22, 29
1,1,1-Trichloroethane	232	120	Chemical intermediate for vinylidene chloride		Non-cyclic halogenated alkane	22	25	Ethane Ethylene dichloride	5, 29, 35
Trichloroethylene	52 c 42	25 c 15	Chain terminator for polymerization of polyvinyl chloride	Solvent in spot removers	Non-cyclic halogenated alkene	12	18	Ethylene dichloride Acetylene	21, 29, 35
Perchloroethylene	122 32 NA	80 20 NA	Chemical intermediate for fluorocarbons 113, 114, 115, 116 other applications - heat exchanger fluid; pharmaceuticals	Solvent in textile spotting fluids Solvent for pre-laundry garment sprays	Non-cyclic halogenated alkene	12	NA	Ethylene dichloride Paraffins	35, 36, 38

NA - Not Available

^aRadical derived^bOnly solvent uses within this category are listed.

TABLE 3-19. SOLVENTS FOR SPECIALTY LUBRICANTS^a

OTS Use Code No: 352-1271

EXPOSURE POTENTIAL: Occupational: 1.90

Consumer: 2.25

Solvent Name	Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Data ^b	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent(s)	References
Trichloroethylene	62	25	Chain terminator for polymerization of polyvinyl chloride Anesthetics Heat transfer medium Exports		Non-cyclic halogenated alkenes	12	18	Ketone dichloride Acetylene	21, 29, 35
	NA NA NA	NA NA NA							
	< 42	< 15		Solvents for lubricants					

NA - Not Available

^aRadon derived

^bOnly solvent uses within this category are listed.

TABLE 3-20. SOLVENTS FOR FOOD^aOTS Use Code No: 352-000a^bEXPOSURE POTENTIAL: Occupational: 2.58
Consumer: 1.50

Solvent Name	X Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Methylene chloride	192	150	Vapor pressure depressant in aerosol sprays Plastics processing	Solvent for extracting caffeine, butter, edible fats and hops beer flavoring	Non-cyclic halogenated alkane	19	5	Methane Ethanol	29, 35
	122	86							
	NA	NA							
Trichloroethylene	62	25	Chain terminator in polymerization of polyvinyl chloride Anesthetics Heat transfer medium	Extraction solvent for food		12	18		21, 29, 35
	NA	NA							
	NA	NA							

NA - Not Available

^aRadon derived^bRadon was unable to derive a use code number for this category.^cOnly solvent uses within this category are listed.

TABLE 3-21. TAR REMOVERS FOR CLEANING AND MAINTENANCE

OTS Use Code No: 366-04000
 EXPOSURE POTENTIAL: Occupational: 3.00
 Consumer: 3.00

Solvent Name	Σ Total Consumption	Annual Consumption (99 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Chloronaphthalenes	NA	NA	Varnishes, resins, and gums		Polynuclear aromatic	NA	0	Naphthalene	13, 41
	NA	NA	Water-, flame-, insect-, and acid-proofing of fibrous bodies						
	NA	NA	Condenser impregnation						
	NA	NA	Heat transfer medium						
	NA	NA	Plasticizers						
	NA	NA	Moisture- and flame-proofing of covered wire and cable						
N,N-Dimethylformamide	NA	NA		Carbon softener and remover	Amide	4	13	Dimethylamine	5, 22, 29
	NA	NA	Gasoline additive						
	NA	NA	Organic synthesis						
	NA	NA	Quench for hot-dip tinned articles						
	NA	NA	Carboxylation rxn. catalyst						
	NA	NA		Cleaning mixtures for carbonaceous and greasy deposits					

NA - Not Available

^aOnly solvent uses within this category are listed.

TABLE 3-22. SOLVENTS FOR RESEARCH AND DEVELOPMENT

OTS Use Code No: 352-0406
 EXPOSURE POTENTIAL: Occupational: 2.75
 Consumer: 2.92

Solvent Name	Total Consumption (000 lb/yr)	Annual Consumption (000 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Partition	References
						Inhalation	Ingestion		
Dimethyl sulfoxide	NA	NA		Analytical solvent	Sulfoxide	NA	20	Dimethyl sulfoxide	8, 19, 41
Ethyl benzene	962	5530	Synthesis of styrene		Aromatic	12	17	Benzene Ethylbenzene Xylene	21
	22	140	Export						
	< 22	NA		Solvent for laboratory use					
Isobutyl methyl ketone	112	21	Export		Ketone	12	11	Acetone	16, 26, 36
	52	11		Solvent for extraction of metals					
Xylenes	62	363	Production of ethyl benzene		Aromatic	12	NA	Petroleum and coal tar isolate	5, 29
	662	3993	Individual isomers						
	102	605	Gasoline pool and miscellaneous						
	< 92	< 544		Solvent for laboratory use					

NA - Not Available

^aOnly solvent uses within this category are listed.

TABLE 3-23. SOLVENTS FOR CROP PRODUCTION^a

OTS Use Code No: 352-012

EXPOSURE POTENTIAL: Occupational (farmers): 3.24

Consumer: 3.33

Solvent Name	Σ Total Consumption	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Usage ^b	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Initiation	Progression		
Ethyl benzene	962	5530	Synthesis of styrene		Aromatic	12	17	Benzene Xylene Ethylene	21
	22	140	Export						
	< 22	NA		Solvent for agricultural pesticides & sprays					
Xylenes	62	161	Production of ethyl benzene		Aromatic	12	NA	Petroleum and coal tar distillate	5, 29
	662	3993	Individual isomers						
	102	605	Gasoline pool & miscellaneous						
	< 92	< 544		Solvent for agricultural pesticides & sprays					

NA - Not Available

^aRadon derived^bOnly solvent uses within this category are listed.

TABLE 3-24. SOLVENTS FOR ADHESIVES

OTS Use Code No: 352-1009

EXPOSURE POTENTIAL: Occupational (Mfr. of adhesives): 2.07; Occupational (office use): 2.07
Consumer: 2.07

Solvent Name	Σ Total Consumption	Annual Consumption (MT 10/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Acetone	NA NA NA NA NA	90 48 50 35 27 100	Diisopentyl A Diacetone alcohol Eucalyptene glycol Eucalyptene Methyl oxide Methacrylic acid and higher meth- acrylates		Ketone	25	22	Isopropylalcohol Cumene	3, 23
	NA	44	Methyl isobutyl acrylate						
	NA	263	Diisopentyl acrylate						
	NA	476	Methyl methacrylate acrylate						
	NA	115	Pharmaceuticals						
	NA	305	Dicalcium phosphate Miscellaneous						
	NA	NA		Solvent for ad- hesives					
Methyl ethyl ketone	62	30	Miscellaneous		Ketone	19	16	sec-Butyl alcohol Butane	21, 24
Methyl isobutyl ketone	142 112 42	72 21 8	Exports		Ketone	12	11	Acetone	14, 24, 36
Micromerone	972	650	Synthesis of ani- line		Nitrated aromatic	1	2	Benzene	12, 21
1,1,1-Trichloro- ethane	238	120	Chemical interme- diate for vinyl- idene chloride		Non-cyclic halogenated alkane	22	25	Ethane Ethylene dichloride	3, 28, 35
	< 62	< 80		Resin solvent in adhesives					

TABLE 3-24. SOLVENTS FOR ADHESIVES (Continued)

Solvent Name	X Total Consumption	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Toluene	332 12 432 43 82	3220 12 4172 360 776	Benzene mfg. Explosives Gasoline pool Isocyanates Plastic mfg. & rubber chemical solvent (benzene dulyde & benzyl chloride)	Solvent for adhesive formulations, especially those used in pressure-sensitive tapes and labels	Aromatic	12	19	Petroleum isolate	5, 12, 17, 21, 23
Ethylene glycol monoethyl ether	492	80	Synthesis of 2-ethoxyethyl acetate		Ether	19	15	Ethylene oxide Ethanol	29
N,N-Dimethylformamide	< 92 NA	<15 NA	Organic synthesis Gasoline additive Quench for hot-dip tinued articles Carboxylation rxn. catalyst	Solvent for adhesive solvents	Amide	4	13	Dimethylamine Methyl formate	5, 22, 29
Trichloroethylene	NA NA NA 62	NA NA NA 25	Anesthetic Heat transfer medium Experts Chain termination for polymerization of polyvinyl chloride	Solvent in adhesive formulations	Non-cyclic halogenated alkane	12	10	Ethylene dichloride Acetylene	21, 29, 35
	< 42	<15		Solvent for adhesive solvents					

NA - Not Available

^aOnly solvent uses within this category are listed.

TABLE 3-25. SOLVENTS FOR PAPER COATINGS^a

OTS Use Code No: 352-1132-19

EXPOSURE POTENTIAL: Occupational: 2.7

Consumer: Not applicable

Solvent Name	X Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent (s)	References
Methyl isobutyl ketone	112	21	Export		Ketone	12	11	Acetone	14, 24, 34
	702	135		Solvent for protective coatings (paints, lacquers, varnishes, coatings for flat wood paneling, metal cans and coil, and paper)					
Methyl ethyl ketone	62	30	Miscellaneous		Ketone	19	16	sec-Butyl alcohol Butane	21, 24
	72	40		Miscellaneous coatings for metal cans & coil and paper					
Acetone	NA	90	Bisphenol A						
	NA	48	Diacetone alcohol						
	NA	50	Hexylene glycol						
	NA	35	Isophorone						
	NA	27	Methyl oxide						
	NA	100	Methacrylic acid and higher methacrylate						
	NA	44	Methyl isobutyl ketone						
	NA	263	Methyl isobutyl ketone						
	NA	476	Methyl methacrylate						
	NA	115	Pharmaceuticals						
	NA	305	Dicalcium phosphate						
	NA	NA	Miscellaneous						
Xylenes	62	363	Production of ethyl benzene						
	662	3993	Individual isomers		Aromatic	12	NA	Petroleum and coal tar isolate	5, 29
	102	605	Gasoline pool and miscellaneous						
	92	544		Solvent for paints, coatings, and enamels (especially for coating metal cans and coil and paper)					

TABLE 3-25. SOLVENTS FOR PAPER COATINGS (Continued)

Solvent Name	2. Total Consumption	Annual Consumption (000 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent(s)	References
Ethyl benzene	96Z	5580	Synthesis of styrene		Aromatic	12	17	Benzene	21
	2Z	140	Export					Xylene	
	< 2Z	<140		Solvent for coating paper, cans and coil				Ethylene	
Toluene	15Z	3220	Benzene mfg.		Aromatic	12	19	Petroleum Isolate	5, 12, 17, 21, 23
	1Z	92	Explosive production						
	45Z	4140	Gasoline pool						
	4Z	368	Isocyanate production						
	8Z	716	Phenol mfg. & other (benzaldehyde & benzyl chloride)						
	< 7Z	<664		Solvent for carboxylic acids, for coating metal cans and coil; paper)					
Ethyl acetate	3Z	6	Chemical synthesis		Ester	23	MA	Acetic acid Ethanol	21, 23, 29
	< 1Z	0.5		Solvent for coating paper, film and foil					

MA - Not Available

^aMedian derived^bOnly solvent uses within this category are listed.

OTS Use Code No: 352-1299
 TABLE 3-26. SOLVENTS FOR PESTICIDES^a
 Occupational (mfr.): 2.41; Occupational (professional exterminators): 3.25
 Consumer: 3.17

Solvent Name	2 Total Consumption (MT 1b/yr)	Annual Consumption (MT 1b/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Ethylene glycol monobutyl ether	9X	10	Synthesis of 2-butoxyethyl acetate	Solvent in insecticides	Ether	6	7	Ethylene oxide Butanol	29
	12	1	Synthesis of di(2-butoxyethyl)phthalate						
	NA	NA	Pesticide in rust removers						
	<31Z	<35							
Chlorobenzene	29X	110	Mfg. nitrochlorobenzene	Solvent for pesticides	Halogenated aromatic	11	14	Benzene	10, 36
	8Z	30	DOT, silicones						
	8Z	30	Mfg. diphenyl oxides						
	8Z	25	Other (primarily rubber intermediates)						
1,1,1-Trichloroethane	<49Z	<180		Solvent for pesticides	Non-cyclic halogenated alkane	22	25	Ethane Ethylene dichloride	5, 29, 35
	23Z	120	Chemical for intermediates for vinylidene chloride						
	< 6Z	<30							
Methyl isobutyl ketone	11X	21	Export	Solvent for insecticides	Ketone	12	11	Acetone	14, 26, 34
	<10Z	18							
Xylenes	6X	349	Production of ethyl benzene	Solvent for insecticides	Aromatic	12	NA	Petroleum & coal tar isolate	5, 29
	66Z	3812	Individual isomers						
	10X	569	Gasoline pool and miscellaneous						
	9Z	540							

Solvent uses including use as a carrier for agricultural pesticides and sprays

TABLE 3-26. SOLVENTS FOR PESTICIDES (Continued)

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Usage ^b	Chemical Structural Category	Toxicity Ranking		Chemical Parent (s)	References
						Inhalation	Ingestion		
Ethyl benzene	96%	5530	Synthesis of styrene		Aromatic	12	17	Benzene Xylene Ethylene	21
	NA	NA		Carrier for agricultural sprays and pesticides					

NA - Not Available

^a Radian derived^b Only solvent uses within this category are listed.

TABLE 3-27. SOLVENTS FOR REPAIR WORK

OTS Use Code No: 352-042

EXPOSURE POTENTIAL: Occupational: 3.16

Consumer: 3.08

Solvent Name	% Total Consumption	Annual Consumption (000 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Chlorobenzene	29%	110	Mfg. nitrochlorobenzene DPT, silicones Mfg. diphenyl oxide other (primarily rubber intermediates)		Halogenated aromatic	11	14	Benzene	10, 36
	<49%	<190		Solvent for degreasing					
o-Dichlorobenzene	65%	36	Mfg. 3,4-dichloroaniline & other pesticides Mfg. other dyes Miscellaneous uses		Halogenated aromatic	6	1	Benzene	10, 18
	5%	3							
	5%	3							
	<10%	<6		Solvent in engine cleaners					
Cyclohexanone	40%	300	Caprolactam		Ketone	6	9	Cyclohexanone	22, 29
	5%	380	Adipic acid					Phenol	
	<5%	<20		Solvent for metal degreasing					
Ethylene glycol monobutyl ether	9%	10	Synthesis of 2-butoxyethyl acetate Synthesis of di-(2-butoxyethyl) phthalate Penetrant in rust removers		Ether	6	7	Ethylene oxide Butanol	29
	1%	1							
	NA	NA							
	<18%	<20		Solvent for metal cleaners					
	<31%	<35		Solvent for varnish removers					
Ethylene glycol monomethyl ether	69%	80	Synthesis of 2-ethoxyethyl acetate		Ether	19	15	Ethylene oxide Ethanol	29
	<9%	<15		Solvent for metal and glass cleaners					

TABLE 3-27. SOLVENTS FOR REPAIR WORK (Continued)

Solvent Name	2 Total Consumption	Annual Consumption (000 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Isobutanol	102	20	Synthesis of amide resins		Alcohol	6	12	Propylene	3
	252	41	Lubricating oil additive						
	402	70	Miscellaneous (including organic synthesis and flavoring for food)						
	<252	<41		Solvent in paint and varnish remover					
Methylene chloride	192	150	Vapor pressure depressant in aerosol sprays		Non-cyclic halogenated alkane	19	5	Methane Methanol	29, 35
	122	86	Plastics processing						
	252	170		Solvent for degreasing					
	442	300		Solvent for paint removers					
Perchloroethylene	122	80	Chemical intermediate for fluorocarbons 113, 116, 115, 116		Non-cyclic halogenated alkene	12	NA	Ethylene dichloride Paraffins	35, 36, 38
	32	20	Other applications (including heat exchanger fluid and pharmaceuticals)						
	162	106		Solvent for metal degreasing					
	502	200	Aerosol propellants						
Trichlorofluoromethane	282	97	Refrigerant		Non-cyclic halogenated alkane	25	NA	Carbon tetrachloride	21
	102	30	Resin synthesis						
	72	20	Foam blowing agent; miscellaneous uses						
	52	20		Solvent in degreasing					

TABLE 3-27. SOLVENTS FOR REPAIR WORK (Cont inued)

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
1,1,1-Trichloroethane	20%	120	Chemical intermediate for vinylidene chloride	Solvent for cold-cleaning of metals Solvent for vapor degreasing	Non-cyclic halogenated alkane	22	25	Ethylene Ethylene dichloride	5, 29, 35
1,1,2-Trichloro-1,2,2-trifluoroethane	37% 34%	193 177	Aerosols Refrigerants Bleaching agents Polymerization intermediates Synthesis of chlorotrifluoroethylene		Non-cyclic halogenated alkane	25	NA	Perchloroethylene	9, 20
	<22.4	<15							
	55.5%	36.3		Solvent for vapor phase cleaning of metal and electronic parts					
	>16.5%	10.6		Solvent for cold-cleaning electronic parts					
N,N-Dimethylformamide	5.6%	3.7	Gasoline additive Organic synthesis Quench for hot-dip tinned articles Carboxylation rxn. catalyst	Solvent for drying	Alkalo	4	13	Dimethylamine Methyl formate	5, 22, 29
	NA	NA							
	NA	NA		Solvent in paint strippers					
Trichloroethylene	NA NA NA 6%	NA NA NA 25	Anesthetics Heat transfer medium Exports Chain terminator for polymerization of polyvinyl chloride		Non-cyclic halogenated alkane	12	18	Ethylene dichloride Paraffins	21, 29, 35
	90%	20		Solvent for metal degreasing; cold metal cleaning; vapor degreasing					
	380	380							

NA - Not Available

^aOnly solvent uses within this category are listed.

TABLE 3-28. SOLVENTS FOR SURFACE CLEANING AND CONDITIONING^a

OTS Use Code No: 352-0645

EXPOSURE POTENTIAL: Occupational: 2.83

Consumer: Not applicable

Solvent Name	Σ Total Consumption	Annual Consumption (000 lb/yr)	Non-Solvent Uses	Specific Solvent Use ^b	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Chlorobenzene	29Z	110	Mfg. nitrochlorobenzene		Halogenated aromatic	11	14	Benzene	10, 36
	8Z	30	WPT, silicones						
	8Z	30	Mfg. diphenyl oxide						
	6Z	25	Other (primarily rubber intermediate)						
	<49Z	<190		Solvent for degreasing					
Cyclohexanone	40Z	300	Caprolactam		Ketone	6	9	Cyclohexanone	22, 29
	55Z	380	Adipic acid					Phenol	
	< 5Z	<20		Solvent for metal degreasing					
Ethylene glycol monobutyl ether	9Z	10	Synthesis of 2-butoxyethyl acetate		Ether	6	7	Ethylene oxide	29
	1Z	1	Synthesis of 41-(2-butoxyethyl) phthalate					Butanol	
	NA	NA	Penetrant in rust removers						
	<18Z	<20		Solvent for metal cleaners					
Ethylene glycol monorthyl ether	49Z	80	Synthesis of 2-ethoxyethyl acetate		Ether	19	15	Ethylene oxide	29
	9Z	<15		Solvent for metal and glass cleaners				Ethanol	
Methylene chloride	19Z	150	Vapor pressure depressant in aerosol sprays		Non-cyclic halogenated alkane	19	5	Methane	29, 35
	12Z	86	Plastics processing					Methanol	
	25Z	170		Solvent for degreasing					
	44Z	300		Solvent for paint removers					

TABLE 3-28. SOLVENTS FOR SURFACE CLEANING AND CONDITIONING (Continued)

Solvent Name	2 Total Consumption	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Pentachloroethylene	122	80	Chemical intermediate for fluorocarbons other applications (including heat exchanger fluid and pharmaceuticals)		Non-cyclic halogenated alkane	12	NA	Ethylene dichloride Paraffins	35, 36, 38
Trichlorofluoromethane	502	200	Aerosol propellants	Solvent for metal degreasing					
	282	97	Refrigerants						
	102	30	Resin synthesis		Non-cyclic halogenated alkane	25	NA	Carbon tetrachloride	21
	72	20	Foam blowing agent; miscellaneous uses						
	52	20		Solvent in degreasing					
1,1,1-Trichloroethane	202	120	Chemical intermediate for vinylidene chloride		Non-cyclic halogenated alkane	22	25	Ethene Ethylene dichloride	5, 29, 35
	372	193		Solvent for cold-cleaning of metals					
	342	177		Solvent for vapor degreasing					
1,1,2-Trichloro-1,2,2-trifluoroethane	<22.4	<15	Aerosols Refrigerants Blowing agent Polymer intermediate Synthesis of chlorotrifluoroethylene		Non-cyclic halogenated alkane	25	NA	Pentachloroethylene	9, 20
	552	36.3		Solvent for vapor-phase cleaning of metal parts					
	>16.52	10.8		Solvent for cold-cleaning of electronic parts					
	5.62	3.7		Solvent for drying					

TABLE 3-28. SOLVENTS FOR SURFACE CLEANING AND CONDITIONING (Continued)

Solvent Name	X Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Trichloroethylene	NA	NA	Anesthetics		Non-cyclic halogenated alkane	12	18	Ethylene dichloride Acetylene	21, 29, 35
	NA	NA	Heat transfer medium						
	NA	NA	Exports						
	62	25	Chair terminator for polymerization of polyvinyl chloride						
Acetone	902	20		Solvent for metal cleaning; cold metal cleaning; vapor degreasing	Ketone	25	22	Isopropanol Camene	5, 23
	NA	90	Bisphenol A						
	NA	48	Diacetone alcohol						
	NA	50	Hexylene glycol						
	NA	35	Inophorone						
	NA	27	Mesityl oxide						
	NA	100	Methacrylic acid & higher methacrylates						
	NA	44	Methyl isobutyl carbinol						
	NA	263	Methyl isobutyl ketone						
	NA	476	Methyl methacrylate						
	NA	115	Pharmaceuticals						
	NA	NA	Dicalcium phosphate						
	NA	NA		Solvent for cleaning & drying of printed circuits					

NA - Not Available

^aRadium derived^bOnly solvent uses within this category are listed.

TABLE 3-29. SOLVENTS FOR PRINTING OPERATIONS

OTS Use Code No: 352-231

EXPOSURE POTENTIAL: Occupational: 2.74

Consumer: Not applicable

Solvent Name	Annual Consumption (MM lb/yr)	Non-Solvent Use	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
					Inhalation	Ingestion		
1,1,1-Trichloroethane	232	120	Chemical intermediate for vinylidene chloride	Non-cyclic halogenated alkane	22	25	Ethane Ethylene dichloride	5, 29, 35
	< 62	< 30						
	492	80	Synthesis of 2-ethoxyethyl acetate	Ether	19	15	Ethylene oxide Ethanol	29
Ethylene glycol monoethyl ether	92	15						
Ethyl acetate	32	6	Chemical synthesis					
Toluene	< 172	< 34		Ester	23	23	Acetic acid Ethanol	21, 23, 29
	352	3220	Benzene mfg.					
	12	92	Explosives					
	432	4140	Gasoline pool					
	84	368	Isocyanates	Aromatic	12	19	Petroleum isolate	5, 12, 17, 21, 23
Cyclohexanone	82	736	Phenol mfg. & other (benzaldehyde & benzyl chloride)					
	< 72	< 644						
	402	300	Caprolactam					
	552	380	Adipic acid	Ketone	6	9	Cyclohexanone Phenol	24, 29
	NA	NA						
Diethylene glycol	72	20	Natural gas dehydration and surfactants					
	72	20	Plastics and surfactants	Glycol	NA	26	Ethylene oxide	22, 29
	302	95	Polyurethanes and unsaturated polyester					
	122	38	Textile agents					
	132	41	Triethylene glycol					
	242	57	Misc. and export					
	NA	NA						

TABLE 3-29.

Solvent Name	Σ Total Consumption	Annual Consumption (MT llyr)	Non-Solvent Uses	Specific Solvent Usage ^a	Chemical Structural Category	Toxicity Ranking Inhalation	Chemical Percent (%)	References
Tetraethylene glycol	172 302	19 30	Innocent Natural gas dehydration	Solvent for inks	Glycol	NA	Ethylene Glycol	29, 31
	82	9	Polyester and poly-urethane adhesives					
	122	13	Vinyl plasticizer					
	62	6	Export					
	152	17						
o-Dichlorobenzene	652		Mfg. 3, 4-Dichloro-aniline & other pesticides		Halogenated aromatic	6	Benzene	10, 18
	52	3	Mfg. other dyes	Solvent in de-inking preparations				
	52	3	Miscellaneous uses					
	<102	6						
Acetone	NA	50	Biophenol A		Ketone	25	Isopropanol Camphor	5, 23
	NA	48	Diacetone alcohol					
	NA	50	Neoprene glycol					
	NA	35	Diisobutyl ketone	Solvent for inks				
	NA	22	Methyl oxide					
	NA	100	Methacrylic acid and higher methacrylates					
	NA	44	Methyl isobutyl carbonyl					
	NA	263	Methyl isobutyl ketone					
	NA	476	Methyl methacrylate					
	NA	115	Pharmaceuticals	Solvent in products - Clin of Inks	Alcohol	19	Petroleum Synthetics gas.	21, 24, 25
	NA	NA	Dicalcium phosphate					
	NA	<305						
Petroleum	42	360	Acetic acid mfg.					
	102	70	DPR mfg.					
	452	3102	Formaldehyde mfg.					
	42	300	Methyl halides					
	82	600	Methyl methacrylates					
	42	300	Methylammonia					
	152	1000	Miscellaneous uses (including mfg. glycol ethers and formaldehyde inhibitors)					
	< 92	< 660	Solvent in products - Clin of Inks					

TABLE 3-29. SOLVENTS FOR PRINTING OPERATIONS (Continued)

Solvent Name	Σ Total Consumption (ppm 10/yr)	Annual Consumption (ppm 10/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
H ₂ N-Dimethyl-formamide	NA	NA	Gasoline additive Organic synthesis Quench for hot-dip tinned articles Carboxylation rxn. catalyst		Amide	4	11	Dimethylamine Methyl formate	5, 22, 29
Diethylene glycol monobutyl ether	22X 32X	NA 3 5	Coalescing agent in latex paints Chemical intermediate for diethyl-amine glycol mono-butyl ether acetate	Solvent in printing inks	Ether	NA	21	Ethylene oxide Butanol	29
Methyl ethyl ketone	62X < 62X	30 < 30	Miscellaneous	Extractive solvent in production of printing inks	Ketone	19	16	sec-Butyl alcohol Butane	21, 24
Nitrobenzene	97X < 1.5X	650 < 10	Synthesis of and-lime	Solvent for cellulose ethers used in printing inks	Nitrated aromatic	1	2	Benzene	12, 21
Ethylene glycol monobutyl ether	NA 9X 12X	NA 10 1	Penetrant in rust removal Synthesis of 2-butoxyethyl acetate Synthesis of di-(2-butoxyethyl) phthalate		Ether	6	7	Ethylene oxide Butanol	29
	< 31X	< 35		Solvent for inks					

NA - Not Available

^aOnly solvent uses within this category are listed.

TABLE 3-30. SOLVENTS FOR PAINT AND ALLIED PRODUCTS

OTS Use Code No: 352-18

EXPOSURE POTENTIAL: Occupational: (Mfr. of paints): 1.90; Occupational (painters): 2.82

Consumer: 3.08

Solvent Name	2 Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Amyl acetate	NA	NA	Textile printing and finishing		Ester	12	NA	Amyl alcohol Acetic acid	22, 24
	NA	NA		Nitrocellulose solvent					
	NA	NA		Solvent for surface coating of flat wood paneling					
	NA	NA		Paint and lacquer solvent					
	NA	NA		Solvent for airplane repairs					
	NA	NA		Solvent for water-proof coatings					
Ethyl acetate	38	6	Chemical synthesis		Ester	23	23	Acetic acid Ethanol	21, 23, 29
		11.5		Solvent for coatings: Wood-furniture & fixtures					
		5.0		Metal furniture & fixtures					
		5.4		Automotive topcoat					
		1.0		Automotive primer					
		0.8		Automotive after-market and misc.					
		2.0		Trucks and buses					
		1.0		Machinery and equipment					
	702	0.5		Paper, film and foil					
		1.0		Factory-finished bldg. prodn.					
		5.8		Other product finishes					
		29		Auto finishing					
		55		Paint thinner and miscellaneous					

TABLE 3-30. SOLVENTS FOR PAINT AND ALLIED PRODUCTS (Continued)

Solvent Name	X Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Diethylene glycol	7X	20	Natural gas dehydration		Glycol	NA	26	Ethylene oxide	22, 29
	7Z	20	Plastics and surfactants						
	30X	95	Polyurethane and unsaturated polyester						
	12X	38	Tricellulose						
	13X	43	Tricellulose glycol						
	24X	57	Misc. and export						
				Solvent for wood stain					
Triethylene glycol	17X	19	Humectant		Glycol	NA	27	Ethylene glycol Ethylene oxide	29, 33
	30X	30	Natural gas dehydration						
	8X	9	Polyester and polyurethane resins						
	12X	13	Vinyl plasticizer						
	6X	6	Export						
				Lacquer solvent					
Xylenes	6X	363	Production of ethyl benzene		Aromatic	12	NA	Petroleum and coal tar isolate	5, 29
	65X	3993	Individual isomers						
	10X	605	Gasoline pool and miscellaneous						
				Solvent for paints, coatings, enamels, lacquers, varnishes, especially in coating metal cans & coil; and paper)					
	9X	544							
Toluene	35X	3220	Benzene mfg.		Aromatic	12	19	Petroleum isolate	5, 12, 17, 21, 23
	1X	92	Explosives production						
	45X	4140	Gasoline pool						
	4X	368	Isocyanates mfg.						
	8X	736	Phenol mfg. & other (benzaldehyde & benzyl chloride)						
	< 7X	< 694		Solvent for surface coatings (paints, lacquers, varnishes for coating metal cans and coil; paper)					

TABLE 3-30. SOLVENTS FOR PAINT AND ALLIED PRODUCTS (Continued)

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Ethyl benzene	96%	5530	Synthesis of styrene		Aromatic	12	17	Benzene Xylene Ethylene	21
	22	140	Export						
	24	140		Solvent for paints, varnishes, coatings, enamel; solvent for coating paper, cans and coil					
Methyl isobutyl ketone	11%	21	Export		Ketone	12	11	Acetone	14, 24, 34
	70%	135		Solvent for protective coatings (paints, lacquers, varnishes, coatings for flat wood paneling, metal cans and coil, paper)					
Cyclohexanone	40%	300	Caprolactam Adipic acid		Ketone	6	9	Cyclohexane Phenol	22, 29
	55%	380							
	5%	20		Solvent for lacquers and other protective coatings (e.g., in coating metal cans and wood staves)					
Methyl ethyl ketone	6%	30	Miscellaneous		Ketone	19	16	sec-Butyl alcohol Butane	21, 24
	12%	62		Acrylic coatings solvent					
	14%	72		Nitrocellulose coating solvent					
	34%	170		Vinyl coatings solvent					
	7%	46		Miscellaneous coatings (includes paper, cans, coil)					

TABLE 3-30. SOLVENTS FOR PAINT AND ALLIED PRODUCTS (Continued)

Solvent Name	Σ Total Consumption (MM lb/yr)	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent (s)	References
						Inhalation	Log ₁₀ LD ₅₀		
Acetone	NA	90	Bisphenol A	Solvents for paints, varnishes and lacquers Solvents for thinner and wash solvents	Ketone	25	22	Isopropanol Cumene	5, 23
	NA	48	Diacetone alcohol						
	NA	50	Hexylene glycol						
	NA	35	Isothorone						
	NA	27	Mesityl oxide						
	NA	100	Methacrylic acid and higher methacrylates						
	NA	44	Methyl isobutyl carbinol						
	NA	263	Methyl isobutyl ketone						
	NA	476	Methyl methacrylate						
	NA	115	Pharmaceuticals						
Ethylene glycol monobutyl ether	NA	80	Dicalcium phosphate						
	NA	120							
	NA	NA	Penetrant in rust removers		Ether	6	7	Ethylene oxide Butanol	29
	92	10	Synthesis of 2-butoxyethyl acetate						
	12	1	Synthesis of di-(2-butoxyethyl) phthalate						
Ethylene glycol monoethyl ether	412	45		Solvent for protective coatings (including metal cans, coil, furniture, appliances; alkyd baking enamels, nitrocellulose lacquers; coatings for flat wood products)					
	492	80	Synthesis of 2-ethoxyethyl acetate	Solvent for protective coatings (including nitrocellulose lacquers, alkyd enamels, baking enamels, and phenolic varnishes. Used in coating cans and coil)	Ether	19	15	Ethylene oxide Ethanol	29
	332	55							

TABLE 3-30. SOLVENTS FOR PAINT AND ALLIED PRODUCTS (Continued)

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Diethylene glycol monobutyl ether	25X	3	Coating agent in latex paints	Solvent for high temperature baked enamels and other coatings	Ether	NA	21	Ethylene oxide	29
	33X	5	Chemical intermediate for diethyl ether acetate						
	42X	< 7						Butanol	
Microbenzene	97X	650	Synthesis of aniline	Solvent for cellulose ethers	Nitrated aromatic	1	2	Benzene	12, 21
	1.52	10							
Methanol	42	300	Acetic acid mfg.	Solvent for coating metal and fabrics	Alcohol	19	24	Methane	21, 24, 34
	102	700	DMT mfg.						
	42	3100	Formaldehyde mfg.						
	42	300	Methyl halides						
	82	600	Methyl methacrylates						
	42	300	Methamines						
	152	1000	Miscellaneous uses (including glycol methyl ethers and formaldehyde inhibitors)						
	<102	NA							
n-Butyl Alcohol	102	56	Amine resins	Surface coating solvents (in paints, lacquers, coatings, for metal furniture, cans and cull)	Alcohol	6	3	Propylene	5, 29
	182	100	Glycol ethers						
	152	84	Miscellaneous chemical synthesis						
	102	56	n-Butyl acetate						
	52	28	n-Butyl acrylate						
	122	67	Plasticizers						
	92	50	Exports						
	212	117							

TABLE 3-30. SOLVENTS FOR PAINT AND ALLIED PRODUCTS (Continued)

Solvent Name	% Total Consumption	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Isobutanol	10%	20	Synthesis of amide		Alcohol	6	12	Propylene	3
	25%	41	Gasoline additive						
	40%	70	Lubricating oil additive						
			Miscellaneous (including organic synthesis and flavoring for food)						
	25%	41		Solvent for paints and lacquers in paint and varnish remover					
N,N-Dimethylformamide	NA	NA	Gasoline additive		Amide	2	13	Dimethylamine Methyl formate	5, 22, 29
			Organic synthesis						
			Quench for hot-dip tinned articles						
			Carboxylation rxn. catalyst						
	NA	NA		Solvent for coatings					

NA - Not Available

^a Only solvent uses within this category are listed.

TABLE 3-31. SOLVENTS FOR PETROLEUM REFINING

OTS Use Code No: 352-20

EXPOSURE POTENTIAL: Occupational: 1.82

Consumer: Not applicable

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Dimethyl sulfoxide	MA	MA		Solvent for BTX extraction from hydrocarbon feedstocks	Sulfoxide	MA	20	Dimethyl sulfide	8, 19, 41
Methanol	4% 10% 45% 8%	300 700 3100 600	Acetic acid mfg. Air mfg. Formaldehyde mfg. Methyl methacrylate Styrene Methylamines Miscellaneous uses (including glycol ether and formaldehyde inhibitor)		Alcohol	19	24	Methane Synthesis gas	21, 24, 34
	4% 15%	300 1000							
	4%	300	Methyl halides						
	<10%	MA		Solvent in refining gasoline and heating oil					
Microbenzene	97%	650	Synthesis of aniline		Nitrated aromatic	1	2	Benzene	12, 21
	<1.5%	<10							
Triethylene glycol	17% 30%	19 30	Humectant Natural gas dehydration Polyester and polyurethane resins Vinyl plasticizer Export		Glycol	MA	27	Ethylene oxide Ethylene glycol	29, 33
	8% 12% 6%	9 13 6							
	<12%	<13		INDEX extraction solvent					
Methyl ethyl ketone	6%	30	Miscellaneous		Ketone	19	16	sec-Butyl alcohol Butane	21, 24
	7%	40		Lube oil dewax by solvent extraction					

MA - Not Available

^aOnly solvent uses within this category are listed.

TABLE 3-32. SOLVENTS FOR FURNITURE REPAIR AND REFINISHING

OTS Use Code No: 352-0421

EXPOSURE POTENTIAL: Occupational: 3.08

Consumer (hobby): 3.08

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
o-Dichlorobenzene	652	36	Mfg. 3,4-dichloroaniline & other pesticides	Solvent in paint removers	Halogenated aromatic	6	1	Benzene	10, 18
	52	3	Mfg. other dyes						
	<102	<6	Miscellaneous uses						
Ethylene glycol monobutyl ether	NA	NA	Penetrant in rust removers	Solvent in varnish removers	Ether	6	7	Ethylene oxide Butanol	29
	92	10	Synthesis of 2-butoxyethyl acetate						
	12	1	Synthesis of di(2-butoxyethyl) phthalate						
Ethylene glycol monoethyl ether	<312	<35	Synthesis of 2-ethoxyethyl acetate	Solvent for varnish removers	Ether	19	15	Ethylene oxide Ethanol	29
	492	80							
	<92	<15							
Cyclohexanone	402	300	Caprolactam Adipic acid	Solvent for paint remover	Ketone	6	9	Cyclohexane Phenol	22, 29
	552	380							
	NA	NA							
Isobutanol	102	20	Synthesis of amide resins Lubricating oil additive Miscellaneous (organic synthesis and flavoring for food)	Solvent for varnish removers	Alcohol	6	12	Propylene	3
	252	41							
	402	70							
	<252	<41							

TABLE 3-32. SOLVENTS FOR FURNITURE REPAIR AND REFINISHING (Continued)

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Methylene chloride	192	150	Vapor pressure de-pressant in aerosol sprays		Non-cyclic halogenated alkane	19	5	Methane Methanol	29, 35
H, H-Dimethyl formamide	442	300		Solvent in paint removers					
	NA	NA	Gasoline additive Organic synthesis Quench for hot-dip tinned articles Carboxylation rxn. catalyst		Amide	4	13	Dimethylamine Methyl formate	5, 22, 29
	NA	NA		Solvent in paint strippers					

NA - Not Available

^a Only solvent uses within this category are listed.

TABLE 3-33. SOLVENTS FOR HYDRAULIC FLUIDS FOR TRANSPORTATION EQUIPMENT^a

OTS Use Code No: 352-1252-28

EXPOSURE POTENTIAL: Occupational (mechanics and service station operators): 3.16
Consumer: 2.32

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Ethylene glycol monobutyl ether	92	10	Synthesis of 2-but-oxethyl acetate	Solubiliser in brake fluid	Ether	6	7	Ethylene oxide Butanol	29
	12	1	Synthesis of di(2-butoxyethyl) phthalate						
	NA	NA	Pestitrent in rust removers						
	<102	<20							
Ethylene glycol monoethyl ether	492	80	Synthesis of 2-ethoxyethyl acetate	Solvent in hydraulic brake fluids	Ether	19	15	Ethylene oxide Ethanol	29
	< 92	<15							
Diethylene glycol monobutyl ether	252	3	Coalescing agent in latex paints	Diluent for hydraulic brake fluids	Ether	NA	21	Ethylene oxide Butanol	29
	312	5	Chemical intermediate for diethylene glycol mono-butyl ether acetate						
	NA	NA							

NA - Not Available

^a Radian derived

^b Only solvent uses within this category are listed.

TABLE 3-34. SOLVENTS FOR ROLL COATINGS^aOTS Use Code No: 352-^b

EXPOSURE POTENTIAL: Occupational: 2.5

Consumer: Not applicable

Solvent Name	Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking		Chemical Percent(s)	References
						Inhalation	Ingestion		
Methanol	42	300	Acetic acid mfg.		Alcohol	19	24	Methane Synthesis gas	21, 24, 34
	102	700	DHF mfg.						
	452	3100	Formaldehyde mfg.						
	42	300	Methyl halides						
	82	600	Methyl methacrylates						
	42	300	Methylamines						
	42	300	Miscellaneous uses						
	152	1000	(including glycol methyl ethers and formaldehyde inhibitor)						
n-Butyl alcohol	<102	NA		Solvent in mfg. coated fabrics	Alcohol	6	3	Propylene Synthesis gas Ethylene Aluminum alkyls	5, 29
	102	60	Amine resins						
	142	79	glycol ethers						
	152	85	liq. chem. syn-thesis						
	122	68	n-Butyl acetate						
	72	40	acrylates						
	122	68	Plasticizers						
	102	60	Exports						
	<212	<117		Solvent for coating metal and cans and coil					
Ethylene glycol monobutyl ether	NA	NA	Penetrant in rust removers		Ether	6	7	Ethylene oxide Butanol	29
	92	10	Synthesis of 2-butoxyethyl acetate						
	12	1	Synthesis of di-(2-butoxyethyl) phthalate						
	412	45		Solvent for protective coatings (including metal cans, coil, furniture, alkyd baking enamels, nitrocellulose lacquers and coatings for flatwood paneling)					

TABLE 3-34. SOLVENTS FOR ROLL COATINGS (Continued)

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Ethylene glycol monoethyl ether	49%	80	Synthesis of 2-ethoxyethyl acetate	Solvent for protective coatings (nitrocellulose lacquers, alkyd resins, enamels, epoxy coatings, and phenolic varnishes. Used in coating metal cans and coil)	Ether	19	15	Ethylene oxide Ethanol	29
	33%	55							
Methyl isobutyl ketone	11%	21	Export	Solvent for protective coatings (paints, lacquers, varnishes, coatings for flatwood paneling, metal cans and coil, and paper)	Ketone	12	11	Acetone	14, 24, 34
	70%	135							
Cyclohexanone	40%	300	Caprolactam	Solvent for lacquers and other protective coatings (e.g., in coating metal cans and wood stains)	Ketone	6	9	Cyclohexane Phenol	22, 29
	55%	380	Adipic acid						
Methyl ethyl ketone	6%	30	Miscellaneous	Nitrocellulose coatings solvent Vinyl coatings solvent Misc. coatings for cans, coil and paper	Ketone	19	16	sec-Butyl alcohol Butane	21, 24
	14%	73							
	34%	170							
	7%	40							

TABLE 3-34. SOLVENTS FOR ROLL COATINGS (Continued)

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking		Chemical Parent (e)	References
						Inhalation	Ingestion		
Triethylene glycol	172	19	Humectant	Solvent for water-borne coatings for flatwood paneling	Glycol	NA	27	Ethylene oxide Ethylene glycol	29, 31
	302	30	Natural gas dehydration						
	82	9	Polyester and polyurethane resins						
	122	13	Vinyl plasticizer						
	62	6	Export						
Xylenes	NA	NA							
	62	363	Production of ethyl benzene	Solvent for paints, coatings and enamels especially for roll coating metal cans and coil and paper)	Aromatic	12	NA	Petroleum and coal tar isolate	5, 29
	662	3993	Individual isomers						
	102	605	Gasoline pool and misc.						
	92	544							
Ethyl benzene	962	5530	Synthesis of styrene	Solvent for paints, varnishes, coatings and enamels (used in coating metal cans and coil)	Aromatic	12	17	Benzene Xylene Ethylene	21
	22	140	Export						
	< 22	<140							
Toluene	352	3220	Benzene mfg.	Solvent for surface coatings (varnishes for coating metal cans and coil; paper)	Aromatic	12	19	Petroleum isolate	5, 12, 17, 21, 23
	12	92	Explosive production						
	452	4140	Gasoline pool						
	42	368	Isocyanate production						
	82	736	Phenol mfg. & other (benzaldehyde & benzyl chloride)						
	< 72	<644							

TABLE 3-34. SOLVENTS FOR ROLL COATINGS (Continued)

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Amyl acetates	NA	NA	Textile finishing and printing		Ester	12	NA	Amyl alcohol Acetic acid	22, 24
	NA	NA		Solvent for surface coating for wood paneling & water-proof coatings					
Ethyl acetate	32	6	Chemical synthesis		Ester	23	23	Acetic acid Ethanol	21, 23, 29
	< 12	0.5		Solvent for coatings for paper, film, and foil					

NA - Not Available

^aCanadian derived^bCanadian was unable to derive a use number for this category.^cOnly solvent uses within this category are listed.

EXPOSURE POTENTIAL: Occupational: 2.58
Consumer: 1.66

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TABLE 3-35. SOLVENTS FOR PHARMACEUTICALS (Continued)

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Methyl ethyl ketone	6%	30	Miscellaneous		Ketone	19	16	sec-Butyl alcohol Butane	21, 24
N,N-Dimethyl-formamide	NA	NA		Solvent for pharmaceutical mfg.					
	NA	NA	Gasoline additive		Aldehyde	4	13	Dimethylamine Methyl formate	5, 22, 29
	NA	NA	Organic synthesis						
	NA	NA	Quench for hot-dip tinued articles Carboxylation rxn. catalyst						
Xylenes	NA	NA		Solvent for pharmaceutical mfg.					
	6%	363	Production of ethyl benzene		Aromatic	12	NA	Petroleum coal tar isolate	5, 29
	66%	3991	Individual isomer production						
	10%	605	Gasoline pool & misc.						
Toluene	NA	NA		Solvent for pharmaceutical mfg.					
	3%	3220	Benzene manufacture		Aromatic	12	19	Petroleum isolate	5, 12, 17, 21, 23
	1%	92	Explosives production						
	4%	4140	Gasoline pool						
	4%	369	Isocyanates production						
	8%	736	Phenol manufacture & other (benzaldehyde & benzyl chloride)						
	< 7%	< 644		Solvent for pharmaceutical mfg.					

TABLE 3-35. SOLVENTS FOR PHARMACEUTICALS (Continued)

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
n-Butyl alcohol	102 182 152	56 100 84	Amino resins Glycol ethers Misc. chemical synthesis		Alcohol	6	3	Propylene Synthesis gas Ethylene Aluminum alkyls	5, 29
	102 52 122 92	56 28 67 50	n-Butyl acetate Plasticizers Exports						
	NA	NA		Solvent in mfg. pharmaceuticals					
Ethyl ether	252	45	Chemical synthesis (including ethanolamines)		Ether	23	10	Ethylene	5, 25, 29
	32 72	5 10	Medical uses (including denaturant for alcohol & refrigerant)						
	NA	NA		Solvent for pharmaceutical mfg.					
1,1,1-Trichloroethane	232	120	Chemical intermediates for vinylidene chloride		Non-cyclic halogenated alkene	22	25	Ethane Ethylene oxide	5, 29, 35
	NA	NA		Solvent in mfg. pharmaceuticals					
Methylene chloride	192 122	50 86	Vapor pressure depressant in aerosol sprays Plastics processing		Non-cyclic halogenated alkene	19	5	Methane Methanol	29, 35
	NA	NA		Pharmaceutical solvent					
Methyl isobutyl ketone	112 <102	21 <10	Export		Ketone	12	11	Acetone	14, 24, 34

TABLE 3-35. SOLVENTS FOR PHARMACEUTICALS (Cont Inued)

Solvent Name	Σ Total Consumption	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^c	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Injection		
Pyridine	NA	2	Pharmaceuticals		Heterocyclic	2	4	Acetylene Acetaldehyde Coal tar isolates	29
	NA	1	Toxile aq.						
	NA	1	Piperidine aq.						
	NA	2		Solvent primarily in drug aq.					
Ethylene glycol monomethyl ether	492	80	Synthesis of 2-ethoxyethyl acetate		Ether	19	15	Ethylene oxide Ethanol	29
				Solvent in pharmaceutical extraction					

NA - Not Available

^aRadon derived^bRadon derived^cRadon was unable to derive a use code number for this category^dOnly solvent uses within this category are listed.

TABLE 3-36. SOLVENTS FOR POLISHES AND RELATED PRODUCTS

OTS Use Code No: 352-2511

EXPOSURE POTENTIAL: Occupational (Mfr. of polishes): 1.99; janitorial services: 2.83
Consumer: 2.76

Solvent Name	X Total Consumption	Annual Consumption (M lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Diethylene glycol	25%	3	Coalescing agent in latex paints	Solvent for soaps, oils and water in household cleaners	Ether	MA	21	Ethylene oxide Butanol	22, 29
	33%	5	Chemical intermediate for diethylene glycol mono-butyl ether acetate						
Ethylene glycol monobutyl ether	<42%	<7		Solvent for liquid household cleaners	Ether	6	7	Ethylene oxide Butanol	29
	MA	MA	Penetrant in rust removers						
	9%	10	Synthesis of 3-butoxyethyl acetate						
Methanol	12	1	Synthesis of di-(2-butoxyethyl) phthalate	Solvent for liquid household cleaners	Alcohol	19	24	Methane Synthesis gas	21, 24, 34
	<18%	<20							
	4%	300	Acetic acid wfg.						
Methanol	10%	700	Wt. wfg.	Solvent for wind-shield washing preps.					
	43%	3100	Formaldehyde wfg.						
	4%	200	Methyl halides						
	8%	600	Methyl methacrylate						
	4%	300	Methylamines						
	15%	1000	Miscellaneous uses (including glycol methyl ethers and formaldehyde inhibitor)						
	22	115							

MA - Not Available

^aOnly solvent uses within this category are listed.

TABLE 3-37. SOLVENTS FOR EXPLOSIVES^a

OTS Use Code No: 352-1206 or 352-170

EXPOSURE POTENTIAL: Occupational (Mfr. of explosives): 2.91

Consumer: Not applicable

Solvent Name	2 Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Ethyl ether	25X	XX	Chemical synthesis		Ether	23	10	Ethylene	5, 22, 29
	3X	5	Medical uses						
	7X	10	Miscellaneous uses (including denaturant for alcohol)						
Acetone	65X	120		Solvent for smokeless powder (used mainly in the purification of explosives)					
	NA	90	Diaphenol A		Ketone	25	22	Isopropenol Cumene	5, 23
	NA	48	Diacetone alcohol						
	NA	50	Neopentyl glycol						
	NA	35	Isopropyl alcohol						
	NA	27	Neopentyl glycol						
	NA	100	Methacrylic acid						
			6 higher methacrylates						
	NA	44	Methyl isobutyl carbinol						
	NA	263	Methyl isobutyl ketone						
	NA	476	Methyl methacrylate						
	NA	115	Pharmaceuticals						
	NA	NA	Dicalcium phosphate						
Amyl acetates	NA	NA		Solvent in mfg. smokeless powder					
	NA	NA	Textile printing & finishing		Ester	12	NA	Acetic acid Amyl alcohol	22, 24
	NA	NA		Smokeless powder solvent					

NA - Not Available

^a Indian derived^b Only solvent uses within this category are listed.

TABLE 3-38. SOLVENTS FOR PRINTING INKS

OTS Use Code No: 352-24

EXPOSURE POTENTIAL: Occupational: 1.90

Consumer: Not applicable

Solvent Name	X Total Consumption	Annual Consumption (000 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent(s)	References
1,1,1-Trichloroethane	23E	120	Chemical intermediates for vinylidene		Non-cyclic halogenated alkane	22	25	Ethylene Ethylene dichloride	5, 29, 35
	< 6E	< 30		Solvent in printing inks					
Ethylene glycol monoethyl ether	49E	80	Synthesis of 2-ethoxyethyl acetate		Ether	19	15	Ethylene oxide Ethanol	29
	9E	15		Solvent in printing inks (including inks for deep-etched lithographic plates)					
Toluene	35E 1E 43E 4E 8E	3220 92 4140 360 736	Benzene mfg. Caprolactam Gasoline pool Isocyanates Phenol mfg. d-Phenol (benzyl chloride)		Aromatic	12	19		5, 12, 17, 21, 23
	< 7E	< 644		Solvent in inks					
Cyclohexanone	40E 55E NA	300 380 NA	Caprolactam Adipic acid		Ketone	6	9	Cyclohexane Phenol	22, 29
Diethylene glycol	7E 7E 30E 13E 13E 24E NA	20 20 95 38 41 57 NA	Natural gas dehydration Planting and aur-lactams Polyurethane and unsaturated polyester Textile agents Triethylene glycol Misc. and export	Solvent for printing inks	Glycol	NA	26	Ethylene oxide	22, 29
				Solvent for printing inks					

TABLE 3-38. SOLVENTS FOR PRINTING INKS (Continued)

Solvent Name	Σ Total Consumption	Annual Consumption (000 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Chablaton	Ingestion		
Triethylamine Glycol	172	19	Monocant	Solvent for printing inks	Glycol	NA	27	Ethylene oxide Ethylene glycol	29, 33
	302	30	Natural gas delivery						
	82	9	Polystyrene and polyurethane resins						
	122	13	Vinyl plasticizer						
	62	6	Export						
Ethyl acetate	152	17		Solvent for printing inks	Glycol	NA	27	Ethylene oxide Ethylene glycol	29, 33
	32	6	Chemical synthesis						
Acetone	<172	<36		Solvent for inks	Ester	23	23	Acetic acid Ethanol	21, 23, 29
	NA	90	Diethylene glycol						
	NA	48	Diethylene glycol						
	NA	50	Diethylene glycol						
	NA	35	Isophorone						
	NA	27	Methyl acetate						
	NA	100	Methacrylic acid and higher methacrylates						
	NA	44	Methyl isobutyl carbamate						
	NA	263	Methyl isobutyl ketone						
	NA	476	Methyl methacrylate						
	NA	115	Pharmaceuticals						
	NA	NA	Dicalcium phosphate						
	NA	<305							
	42	300	Acetic acid mfg.						
	102	700	Formaldehyde mfg.						
Methanol	452	3100	Formaldehyde mfg.	Solvent for inks	Alcohol	19	26	Methane Synthesis gas	21, 24, 34
	42	300	Methyl acetate						
	82	600	Methyl methacrylate						
	42	300	Miscellaneous uses (including mfg. glycol ethers and formaldehyde inhibitor)						
	152	1000							
	<102	NA							

TABLE 3-38. SOLVENTS FOR PRINTING INKS (Continued)

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^a	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent(s)	References
N,N-Dimethyl formamide	NA	NA	Gasoline additive Organic synthesis Quench for hot-dip tinned articles Carboxylation rxn. catalyst		Amide	4	13	Dimethylamine Methyl formate	5, 22, 29
Diethylene glycol monobutyl ether	23E	3	Coalescing agent in latex paints Chemical intermedi- ate for diethyl- ene glycol mono- butyl ether acetate	Solvent for print- ing inks	Ether	NA	21	Ethylene oxide Butanol	29
Methyl ethyl ketone	6E	10	Miscellaneous	Solvent for inks	Ketone	19	16	sec-Butyl alcohol Butane	21, 24
Nitrobenzene	97E	650	Synthesis of ani- line	Extractive solvent in aq. ink	Mixed aromatic	1	2	Benzene	12, 21
	< 1.3E	< 10	Penetrant in rust removers Synthesis of 2- butoxyethyl acetate Synthesis of di- (2-butoxyethyl) phthalate	Solvent for cellu- lose ethers used in printing inks	Ether	6	7	Ethylene oxide Butanol	29
	< 31E	< 35		Solvent for inks					

NA - Not Available

^aOnly solvent uses within this category are listed.

TABLE 3-39. SOLVENTS FOR COATING MAGNETIC WIRE^a

OTS Use Code No: 352-I2601-1461

EXPOSURE POTENTIAL: Occupational (manufacture): 2.91

Consumer: Not applicable

Solvent Name	E Total Consumption	Annual Consumption (lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking		Chemical Parent(s)	References
						Inhalation	Ingestion		
Creosote	15X	26	Antioxidants		Phenol	2	6	Phenol Petroleum isolate Napitha	21, 32
	42	10	Cleaning and disinfecting cycle						
	62	10	Ore flotation						
	22X	38	Phosphate esters						
	15X	26	Resins						
	102	19	Misc. uses						
	11X	20	Exports						
	15X	26		Magnetic wire solvent					
Cresylic acid	21X	MA	Phosphate esters		Phenol	2	6	Petroleum isolate	16, 32
	17X	MA	Phenolic resins						
	17X	MA	Antioxidants						
	6X	MA	Cleaning and disinfectants						
	8X	MA	Ore flotation						
	12X	MA	Miscellaneous						
	17X	MA		Solvent for magnetic wire					

MA - Not Available

^aRadion derived^bOnly solvent uses within this category are listed.

TABLE 3-40. SOLVENTS FOR TEXTILE PROCESSING^a

OTS Use Code No: 352-1368

EXPOSURE POTENTIAL: Occupational: 2.58

Solvent Name	Σ Total Consumption (000 lb/yr)	Annual Consumption (000 lb/yr)	Non-Solvent Uses	Specific Solvent Uses ^b	Chemical Structural Category	Toxicity Ranking Inhalation	Toxicity Ranking Ingestion	Chemical Parent(s)	Reference
Trichloroethylene	< 45	< 15		Solvents for textile sizing	Non-cyclic halogenated alkanes	12	10	Ethylene dichloride	21, 29, 35
	NA	NA	Small amounts as lubricants and heat transfer medium; exports chain terminator for polymerization of vinyl chloride					Acetylene	
Perchloroethylene	NA	NA		Solvents for textile sizing		12	NA	Ethylene dichloride	35, 36, 38
	12E	80	Chemical intermediates for fluorocarbons 113, 114, 115, 116					Paraffins	
	3E	20	Other applications - heat exchanger fluid; pharmaceuticals						
Methylene chloride	NA	NA		Solvent for textile sizing	Non-cyclic halogenated alkanes	19	5	Methane	29, 35
	19E	150	Vapor pressure dependent in air - 100% by weight					Methanol	
	12E	86	Plastics processing - component of fire-retarding compositions						
1,1,1-Trichloroethane	33E	120	Chemical intermediates for vinylidene chloride	Solvent for textile sizing	Non-cyclic halogenated alkanes	22	25	Ethane	5, 29, 35
								Ethylene oxide	

NA - Not Available

^aRadon derived^bOnly solvent uses within this category are listed.

Chemicals with similar chemical structures often exhibit similar chemical, physical, and toxicological properties. For this reason, the solvents in this study were grouped according to their basic chemical structures.

The nature of organic chemical solvents is such that many are included in the same broad chemical categories (e.g., alkanes, alkenes, heterocyclics). In this study, it was sometimes useful to make these broad categories more specific by adding appropriate descriptors. For example, chemicals classified as aromatics were further categorized as either aromatics, halogenated aromatics, or nitrated aromatics. Table 4-1 is a list of chemical structural categories used in this study and the number of solvents in each.

Solvents were grouped in tables prepared for each chemical category. The following information was included about each solvent:

- Chemical name
- Specific solvent uses
- Solvent use categories into which each solvent was grouped
- Exposure potential, both occupational and consumer solvent use category
- Non-solvent uses

- Consumption quantities for solvent and non-solvent uses
- Percentages of total consumption applicable to each use
- Toxicity rankings for inhalation and ingestion
- Primary chemical parents.

Organizing information about each solvent according to chemical structure will be useful if generic regulations are implemented. The information presented in the following tables may be of use in developing generic chemical standards.

TABLE 4-1. CHEMICAL STRUCTURAL CATEGORIES

Chemical Structural Category	Number of Solvents in Category	Table No. for Solvent Category
Halogenated aromatics	3	4-2
Ketones	4	4-3
Polynuclear aromatics	1	4-4
Amides	1	4-5
Non-cyclic halogenated alkenes	2	4-6
Aromatics	3	4-7
Alcohols	3	4-8
Ethers	4	4-9
Non-cyclic halogenated alkanes	4	4-10
Glycols	2	4-11
Phenols	2	4-12
Nitrated aromatics	1	4-13
Sulfoxide	1	4-14
Thione	1	4-15
Heterocyclics	1	4-16
Esters	2	4-17

TABLE 4-2. HALOGENATED AROMATIC SOLVENTS

Solvent Name	X Total Consumption (MM lb/yr)	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Chlorobenzene	49X	190		Solvent for pesticides & degreasing	Solvents for pesticides	2.41 mfg.	3.17	11	14	Benzene	10, 16
					Solvents for repair work	3.25 exterminators	3.08				
					Solvents for surface cleaning and conditioning	3.16					
						2.83					
o-Dichlorobenzene	29X	110	Mfg. of nitrochlorobenzenes								
	8X	30	DOT, silicones								
	8X	30	Mfg. of di-phenyl oxide								
	6X	25	Other (primarily rubber intermediate)								
o-Dichlorobenzene	15X	8		TDI process solvent	Solvents for chemicals	2.24		6	1	Benzene	10, 18
	10X	6		Solvent in paint removers, engine cleaners, deinking preparations	Solvents for repair work	3.16	3.08				
					Solvents for furniture repair and refinishing	3.08	3.08				
					Solvents for printing operations	2.74					
				Solvent for pharmaceutical mfg.	Solvents for pharmaceuticals	2.58	1.66				
o-Dichlorobenzene	NA	NA									
	65X	36	Mfg. of 3,4-dichloronitroline								
	5X	3	Mfg. of other dyes								
	5X	3	Miscellaneous uses								

NA - Not Available

TABLE 4-3. KETONE SOLVENTS

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Acetone	NA	80		Cellulose acetate spinning solvent	Solvents for plastic and rubber materials (not fabricated)	1.90		25	22	Isopropyl alcohol Cumene	5, 23
	NA	10		Solvent for acetylene in cylinders	Solvents for chemicals for brazing, welding and soldering	1.75					
	NA	80		Solvent for paints, varnishes, lacquers	Solvents for paint and allied products	1.90 mfg. 2.82 painters	3.08				
	NA	120		Solvent for thinner and wash solvent							
	NA	100		Chemical processing solvent	Solvent for chemicals	2.24					
	NA	305		Mixing solvent for adhesives; paper coatings; printing inks; smelting powder mfg.; cement, cleaning & drying of printed circuits	Solvents for chemicals Solvents for adhesives Solvents for paper coatings Solvents for printing inks Solvents for cement, cleaning & drying of printed circuits	2.07 mfg. 2.07 office 2.67 1.90 2.74	2.07				
	NA	NA		Solvent for mfg. pharmaceuticals	Solvents for surface cleaning and conditioning Solvents for explosives Solvent for pharmaceuticals	2.58 2.91 2.58	1.66				
	90		Bisphenol A								
	48		Diacetone alcohol								
	50		Hexylene glycol								
	35		Isochlorone								
	27		Mesityl oxide								
	100		Methacrylic acid & higher methacrylates								
	44		Methyl isobutyl carbinol								
	263		Methyl isobutyl ketone								
	476		Methyl methacrylate								
	115		Pharmaceuticals								
	NA		Dicalcium phosphate								

TABLE 4-3. KETONE SOLVENTS (Continued)

Solvent Name	Σ Total Consumption (MM lb/yr)	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	Reference
						Occupational	Consumer	Inhalation	Ingestion		
Methyl ethyl ketone	122	62		Acrylic coatings solvent	Solvents for paints and allied products	1.90 mfg.	3.08	19	16	sec-Butyl alcohol	21, 24
	142	72		Mitocellulose coatings solvent	Solvents for roll coating	2.82 painters				Butane	
	342	170		Vinyl coatings solvent	Solvents for paper coating	2.50					
	72	40		Misc. coatings (includes cans, coils, paper)		2.67					
	142	72		Adhesives solvent							
	72	40		Lube oil dewax by solvent extraction	Solvents for petroleum refining	2.07 mfg.	2.07 office				
	62	30		Extractive solvent in ink	Solvents for printing inks	1.82					
					Solvents for printing operations	1.90					
					Solvents for chemicals	2.74					
				TPA mfg.	Solvents for chemicals	2.24					
Methyl isobutyl ketone	MA	MA		Solvent for pharmaceutical mfg.	Solvent for pharmaceuticals	2.58	1.66				
	62	30	Miscellaneous								
	702	135		Solvent for protective coatings (paints, lacquers, varnishes, coatings for flat wood panelling, metal cans, coils, & paper)	Solvents for allied products	1.90 mfg.	3.08	12	11	Acetone	14, 24, 34
				Solvent for metal extractions	Solvents for research and development	2.82 painters					
	52	11		Chemical processing solvent	Solvents for chemicals	2.50					
	102	18		Solvent for epoxy resin mfg.	Solvents for plastic and rubber materials (not fabricated)	2.67					
	MA	MA		Solvent for insecticides, butadiene, acrylonitrile, etc.	Solvents for pesticides	2.75	2.92				
				Solvent for mineral oils and waxes, pharmaceuticals	Solvents for pharmaceuticals	2.24					
				Solvent for adhesives	Solvents for adhesives	1.90					
	102	18		Solvent for insecticides, butadiene, acrylonitrile, etc.	Solvents for pesticides	2.41 mfg.	3.17				
	62	8		Solvent for adhesives	Solvents for adhesives	3.25 exterminators					
	112	21	Export			2.58	1.66				
						2.07	2.07 office				

TABLE 4-3. KETONE SOLVENTS (Continued)

Solvent Name	Annual Consumption (MT lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential Occupational	Toxicity Ranking Inhalation	Chemical Patent (s)	References
Cyclohexanone			Solvent for lac- quers & other protective coat- ings (e.g., in coating metal cans and wood stains)	Solvents for paint and allied products	1.90 mg. 2.82 painters	6	Cyclohexanone Phenol	22, 29
	58	20	Solvent for crude rubber	Solvents for roll coating plastics and rubber mater- ials and syn- thetics (not fabricated)	2.50 1.90			
			Solvent for spot removers for lea- ther and textiles Degreasing agent	Solvents for spotting agents Solvents for surface clean- ing and condi- tioning	2.74 2.83	2.74		
	NA	NA	Solvent for paint remover	Solvents for repair work Solvents for furniture restoration	3.16 3.08	3.08 3.08		
	NA	NA	Solvent for print- ing ink	Solvents for refinishing printing operations	2.74			
	402 558	300 300	Caprolactam Adipic acid	Solvents for printing ink	1.57			

NA - Not Available

TABLE 4-4. POLYNUCLEAR AROMATIC SOLVENTS

Solvent Name	Σ Total Consumption (100 lb/yr)	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	Reference
						Occupational	Consumer	Inhalation	Ingestion		
Chloronaphthalene				Carbon softener & remover	Tar remover for cleaning & maintenance	3.00	3.00	MA	II	Naphthalene	13, 41
					Tar remover for laundry & dry cleaning	3.16					
				Solvent for rubber, aniline and other dyes	Solvents for plastics and rubber materials and synthetics (not fabricated)	1.90					
					Waxes, mineral & vegetable oils	2.24					
				Varnishes, gums, resins, flame-retardant, acid-proofing, fibrous bodies, Condenser impregnation, Heat transfer medium, Plasticizers, Moisture and flame-proofing of covered wire and cable							

NA - Not Available

TABLE 4-5. AMIDE SOLVENTS

Solvent Name	I Total Consumption (MM lb/yr)	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential Occupational	Toxicity Ranking Inhalation	Chemical Parent(s)	References
N,N-Dimethyl-formamide	NA	NA	NA	Solvent for butadiene and acid resins, & acrylonitrile	Solvents for chemicals	2.24	4	13	Dimethylamine Methyl formate
				Solvent for polyimide, acrylic, and polyurethane films (not fabricated)	Solvents for plastic and rubber materials, synthetic textiles (not fabricated)	1.90			
MA	NA	NA	NA	Solvent for polymer film production					
				Solvent for coatings	Solvents for paint and allied products	1.90 afd, 2.82 painters			
MA	NA	NA	NA	Paint stripper	Solvents for repair work	3.16			
					Solvents for furniture repair and refinishing	3.08			
MA	NA	NA	NA	Printing ink	Solvents for printing operations	2.74			
					Solvents for printing inks	1.90			
MA	NA	NA	NA	Adhesive formulations	Solvents for adhesives	2.07 afd, 2.07 office			
				Solvent for pharmaceutical afd.	Solvent for pharmaceuticals	2.36			
MA	NA	NA	NA	Dye stuffs	Solvents for dye afd.	2.24			
				Electrolyte solutions in high voltage capacitors	Solvents for plain dyed and finished fibers, yarn and fabric	3.08			
MA	NA	NA	NA	Cleaning mixtures for carbonaceous and greasy deposits					
					Solvents for capacitors	1.90			
MA	NA	NA	NA	Gasoline additive	Tar removers for cleaning & maintenance	3.00			
				Organic synthesis	Tar removers for laundry and drycleaning	3.16			

MA - Not Available
 Specific mention of polyamides was found.

TABLE 4-6. NON-CYCLIC HALOGENATED ALKENE SOLVENTS

Solvent Name	Σ Total Consumption (MM lb/yr)	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Trichloroethylene	902	20 380		Solvent for metal degreasing; cold metal cleaning; vapor degreasing Extraction solvent for foods Solvents for cleaning textiles & wool Solvent for adhesives Solvent for lubricants Solvent for textile spotting fluids Solvents for textile siting	Solvents for repair work Solvents for surface cleaning and conditioning Solvents for foods Solvents for laundry and drycleaning Solvents for wool cleaning Solvents for adhesives Solvents for specialty lubricants Solvents for spotting fluids Solvents for textile processing	3.16	3.08	12	18	Ethylene dichloride Acetylene	21, 29, 35
	42	15				2.58	1.50				
						2.41	2.08				
						3.08					
						2.07 mfg.	2.07				
						2.07 office					
						1.90 mfg.					
						2.25 operators					
						2.74	2.74				
						2.58					
	62	25	Chain terminator for polymerization of polyvinyl chloride Small amounts as anesthetics & heat transfer medium; exports								
	MA	MA									

TABLE 4-6. NON-CYCLIC HALOGENATED ALKENE SOLVENTS (Continued)

Solvent Name	2 Total Consumption	Annual Consumption (MW lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Ch. and/or Physical	References
						Occupational	Consumer	Inhalation	Ingestion		
Perchloroethylene	692	438		Drycleaning solvent	Solvents for laundry and drycleaning	2.41	2.08	12	NA	Ethylene dichloride	35, 36, 38
	162	106		Solvent for metal degreasing	Solvents for repair work	3.16	3.08			Paraffins	
	NA	NA			Solvents for surface cleaning and conditioning	2.83					
	NA	NA		Solvent for textile sizing	Solvents for textile processing	2.56					
NA	NA	NA		Solvent for still-masses	Solvents for plastics & rubber materials & synthetics (not fabricated)	1.90					
	NA	NA			Solvents for pre-laundry garment spotting agents	2.74	2.74				
122	80		Chemical intermediates for fluorocarbons 113, 114, 115, 116								
	32	20	Other applications - heat exchanger fluid; pharmaceuticals								

NA - Not Available

TABLE 4-7. AROMATIC SOLVENTS

Solvent Name	X Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	Reference
						Occupational	Consumer	Inhalation	Ingestion		
Xylenes	98	544		Solvents for paints, coatings, adhesives, varnishes (including allyl in coating metal cans, coll., paper)	Solvents for paint and allied products	1.90 mfg.	3.08	12	MA	Petroleum 4 coal tar isolate	5, 19
				Solvents for metal cans, coll., paper)	Solvents for roll coating	2.82 painters					
	92	544		Other solvent uses including use as carrier for agricultural pesticides and sprays	Solvents for paper coating	2.50					
				Solvents for pharmaceutical mfg.	Solvents for crop production	2.67					
	MA	MA		Solvents for pharmaceutical mfg.	Solvents for pesticides	3.24	3.33				
				Solvents for pharmaceutical mfg.	Solvents for crop production	2.41 mfg.	3.17				
	MA	MA		Solvents for pharmaceutical mfg.	Solvents for pesticides	3.25 exterminators					
				Solvents for pharmaceutical mfg.	Solvents for pesticides	2.58	1.66				
	MA	MA		Solvents for dyes	Solvents for cala	2.24					
	MA	MA		Solvents for laboratory use	Solvents for dye production	2.75	2.92				
Toluene	62	363	Production of ethyl benzene								
	662	3993	Individual industrial production								
	102	605	Gasoline pool & misc.								
				Solvent for surface coatings (paints, lacquers; varnishes for coating metal cans & coll; paper)	Solvents for paint and allied products	1.90 mfg.	3.08	12	19	Petroleum 5, 12, 17, isolate 21, 23	
				Solvent for inks	Solvents for roll coating	2.50					
	72	644		Solvents for printing	Solvents for paper coating	2.67					
				Solvents for printing	Solvents for printing	2.74					
				Solvents for printing	Solvents for printing	1.90					
				Solvents for printing	Solvents for printing	2.07 mfg.	2.07				
				Solvents for printing	Solvents for printing	2.07 office					
352	3220		Benzene manufacture								
12	92		Explosives production								
432	4140		Gasoline pool								
43	368		Gasoline pool								
82	736		Phenol manufacture & other (benzaldehyde; benzyl chloride)								

TABLE 4-7. AROMATIC SOLVENTS (Continued)

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Ethyl ben- zene	23	140		Solvent for paints, varnishes, lacquers, stain- ing paper, cane & soil	Solvents for paint and allied products	1.90 mfg. 2.82 painters	3.08	1.2	1.7	Benzene Xylene Ethylene	21
				Solvents for coat- ing paper, cane & soil	Solvents for roll coating Solvents for paper coating	2.50 2.67					
				Solvents for dyes	Solvents for dye production	2.24					
				Carrier for agri- cultural sprays and pesticides	Solvents for crop produc- tion	3.24	3.33				
				Solvents for labo- ratory use	Solvents for pesticides research and development	2.41 mfg. 3.25 exterminators	3.17 2.92				
	962	5530	Synthesis of styrene								
	28	140	Export								

NA - Not Available

TABLE 4-8. ALCOHOL SOLVENTS

Solvent Name	E Total Consumption (MM 2b/yr)	Annual Consumption (MM 2b/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	Reference
						Occupational	Consumer	Inhalation	Ingestion		
Fethanol	258	41		Solvent in paints & lacquers	Solvents for paint and allied products	1.90 mg.	3.08	6	12	Propylene	3
				Solvent in paint & varnish removers	Solvents for furniture repair and refinishing	2.82 pinters	3.08				
					Solvents for repair work						
102		20	Synthesis of acids resins								
258		41	Lubricating oil additive								
408		70	Miscellaneous organic synthetics, flavoring for food								
Methanol											
108	640	20		Industrial process solvent	Solvents for printing operations	2.74		19	24	Methane Synthesis gas	21, 26, 30
					Solvents for printing inks	1.90					
				metal finishes	Solvents for paint and allied products	1.90 mg.	3.08				
					Solvents for allied products	2.82 pinters					
				coated fabrics	Solvents for roll coating	2.50					
				refining gas line & heating oil	Solvents for petroleum refining	1.82					
				Chemical process solvent	Solvents for chemicals	2.26					
				Nylon 66 mfg.	Solvent for dye mfg.	2.26					
				Solvent for windshield washing preparations	Solvents for polished related products	1.99	2.76				
				Solvent in production of pharmaceuticals	Solvents for pharmaceuticals	2.50	1.46				

TABLE 4-8. ALCOHOL SOLVENTS (Continued)

Solvent Name	Y Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	Reference
						Occupational	Consumer	Inhalation	Ingestion		
Methanol (Continued)	42	300	Acetic acid mfg.								
	102	700	DMF mfg.								
	452	3100	Formaldehyde mfg.								
	42	300	Methyl halides								
	42	600	Methyl methacrylates								
	42	300	Methylamines								
	152	1000	Miscellaneous uses (including mfg. of glycol ethers & glycol solubility inhibitors)								
n-Butyl alcohol	212	117		Surface coating solvent (in paints, lacquers, coatings for metal furniture, cans, coll)	Solvents for paint and allied products	1.90 mfg.	3.08	6	3	Propylene Synthesis gas Ethylene Aluminum alkyls	5, 29
	MA	MA		Solvent for pharmaceutical mfg.	Solvent for pharmaceuticals	2.58	1.66				
	102	56	Amine resins		Solvents for roll coating	2.50					
	182	100	Glycol ethers								
	152	84	Misc. chemical synthesis								
	102	56	n-Butyl acetate								
	52	28	n-Butyl acrylate								
	122	67	Plasticizers								
	92	50	Exporters								

MA - Not Available

TABLE 4-9. ETHER SOLVENTS

Solvent Name	Σ Total Consumption (MM lb/yr)	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Ethyl ether	65E	120		Solvent for smokeless powder production	Solvents for explosives	2.24		23	10	Ethylene	5, 24, 29
	MA	MA		Solvent for pharmaceuticals	Solvent for pharmaceuticals	2.58	1.66				
	25E	45	Chemical synthesis (including ethanol amines)	Extractive solvent for fats, oils, waxes, rubber	Solvent for chemicals	2.24					
	3E 7E	5 10	Medical uses (including denaturant for alcohol & refrigerant)	Extraction and concentration of acetic acid							
Ethylene glycol monoethyl ether	9E	15		Solvent for printing inks (including solvent for deep etch lithographic plates)	Solvents for printing operations	2.74		19	15	Ethylene oxide Ethanol	29
	33E	55		Solvent for protective coatings (including nitrocellulose lacquers, alkyd resin solvents, baking enamels, epoxy coatings, and phenolic varnishes. Used in coatings, cans and coll)	Solvents for paint and allied products	1.90 a/g. 2.82 painters	3.08				

TABLE 4-9. ETHER SOLVENTS (Continued)

Solvent Name	Σ Total Consumption (100 lb/yr)	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Patent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Ethylene glycol monobutyl ether (Continued)	92	15		Miscellaneous solvent usage: Adhesives Dyes Hydraulic brake fluid Varnish remover	Solvents for adhesives Solvents for dyes Solvents for hydraulic fluid for transportation equipment Solvents for repair work Solvents for furniture repair and refinishing Solvents for surface cleaning and conditioning Solvents for pharmaceuticals	2.07 mfg. 2.07 office 2.24 3.16 2.32 3.16 3.08 3.08 2.83 2.58 1.66	2.07				
	492	80	Synthesis of 2-ethoxy ethyl acetate	Metal and glass cleaners Pharmaceutical extraction							
	412	45		Solvent for protective coatings (including metal cans, coil, furniture appliances, alkyl baking enamels, nitrocellulose lacquers, coatings for flat wood products)	Solvents for paint and allied products Solvents for roll coatings	1.90 mfg. 2.82 painters 2.50	3.08	6	7	Ethylene oxide Butanol	29
	182	20		Solvent for liquid household cleaners	Solvents for polishes and related products	1.99 mfg. 2.83 janitorial	2.76				
	MA	MA		Solvent for metal cleaners	Solvents for repair work Solvents for surface cleaning and conditioning	3.16 2.83	3.08				

TABLE 4-9. ETHER SOLVENTS (Continued)

Solvent Name	X Total Consumption	Annual Consumption (M lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential	Toxicity Ranking	Chemical Parent(s)	References
						Occupational	Inhalation		
Ethylene glycol monobutyl ether (Continued)	MA	MA		Solvent for brake fluid	Hydraulic fluid for transportation equipment	3.16	2.32		
	312	35		Other misc. solvent usage: insecticides & herbicides; ink	Solvents for printing ink	2.07	1.16		
					Solvents for repair work	1.90	3.08		
					Solvents for maintenance repair and re-finishing	2.74	3.08		
				Varnish removers	Solvents for printing operations	3.16	3.08		
	MA	MA	Penetrant in rust removers						
	92	10	Synthesis of 2-butoxyethyl acetate						
	12	1	Synthesis of di-(2-butoxy-ethyl) phthalate						
Diethylene glycol monobutyl ether	422	7		Solvent for inks	Solvents for printing operations	2.74	MA	21	29
				Solvent for dye baths	Printing inks	1.90			
					Solvents for plate dyed & finished fibers, yarns and fabrics	3.08	1.42		
				Solvent for high temperature baked enamels & ether coatings	Solvents for paint and allied products	1.90 mfg.	3.08		
				Solvent for soaps, oils, water in household cleaners	Solvents for polishes and related products	2.82 painters			
				Diluent for hydraulic brake fluids	Solvents for hydraulic fluid for transportation equipment	1.99 mfg.	2.76		
						2.63 janitorial			
						3.16	2.32		

TABLE 4-9. ETHER SOLVENTS (Continued)

Solvent Name	X Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Diethylene glycol monobutyl ether (Continued)	232	3	Coalescing agent in latex paints								
	332	5	Chemical intermediates for diethylene glycol monobutyl ether acetate								

NA - Not Available

*Solvent application not clear from data. This category used as an example of drying application.

TABLE 4-10. NON-CYCLIC HALOGENATED ALKANE SOLVENTS

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	Reference
						Occupational	Consumer	Inhalation	Ingestion		
1,1,2-Trichloro-1,2,2-ethane	>16.52	10.8	2	Drycleaning solvent	Solvents for laundry and drycleaning	2.41	2.08	25	NA	Perchloroethylene	9, 20
				Solvent for cold cleaning electronic parts	Solvents for repair work	3.16	3.08				
				Solvent for vapor phase cleaning of metal and electronic parts	Solvents for surface cleaning and conditioning	2.83					
				Solvent for drying graphic film	Solvents for fabricated rubber and plastics products	3.00					
Trichlorofluoromethane	52	20	15	Aerosols Refrigerants Blowing agent Polymer intermediate Synthesis of chlorotri-fluoroethylene	Solvent in degreasing	3.16	3.08	25	NA	Carbon tetrachloride	21
	502	200	Aerosol propellants Refrigerant Blowing agent Foam blowing agent; miscellaneous uses		Solvents for repair work	2.83					

TABLE 4-10. NON-CYCLIC HALOGENATED ALKANE SOLVENTS (Continued)

Solvent Name	Σ Total Consumption (MM lb/yr)	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Methylene chloride	442	300		Solvent in paint removers	Solvents for furniture repair and refinishing	3.08	3.08	19	5	Methane Methanol	29, 35
	252	170		Solvent for degreasing	Solvents for repair work Solvents for surface cleaning and conditioning	3.16 2.83					
	NA	NA		Pharmaceutical solvent	Solvents for pharmaceuticals	2.58				1.66	
	NA	NA		Solvent for extracting caffeine, rubber, fats, butters, hops, flavors	Solvents for food	2.58				1.50	
	NA	NA		Solvent for photographic film mfg.	Solvents for fabricated rubber and plastic products	3.00					
	NA	NA		Solvent in mfg. of synthetic fibers	Solvent for plastic and rubber materials and synthetics (not fabricated)	1.90					
	NA	NA		Solvent for textile sizing	Solvents for textile processing	2.58					
	192	150	Vapor pressure depressant in aerosol sprays								
	122	86	Plastics processing								
	NA	NA	Component of fire extinguishing compositions								

TABLE 4-10. NON-CYCLIC HALOGENATED ALKANE SOLVENTS (Continued)

Solvent Name	% Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
1,1,1-Tri-chloroethane	372	193	Solvent for cold cleaning metals Solvent for vapor degreasing Solvent for active ingredients in aerosols for deodorants and antiperspirants - major use Resin solvent in adhesives Solvent in drain cleaners Solvent in shoe polishes Solvent in spot removers Solvent in pesticides Solvent in printing inks Solvent for textile sizing Solvent for pharmaceutical mfg.	Solvent for cold cleaning metals	Solvents for repair work	3.16	3.08	22	25	Ethane	5, 29, 35
	342	177		Solvent for vapor degreasing	Solvents for surface cleaning and conditioning	2.83				Ethylene oxide	
				Solvent for active ingredients in aerosols for deodorants and antiperspirants - major use	Solvents for aerosol personal products	2.24	2.58				
				Resin solvent in adhesives	Solvents for adhesives	2.07 mfg.	2.07				
				Solvent in drain cleaners	Solvents for drain cleaners	1.90	2.91				
				Solvent in shoe polishes	Solvents for shoe polishes	1.90	2.57				
	61	30		Solvent in spot removers	Solvents for spotting agents	2.74	2.74				
				Solvent in pesticides	Solvents for pesticides	2.41 mfg.	3.17				
				Solvent in printing inks	Solvents for printing operations	2.74	3.25 external use				
				Solvent for textile sizing	Solvents for printing inks	1.90					
232	120	Chemical intermediate for vinylidene chloride		Solvent for pharmaceutical mfg.	Solvent for pharmaceuticals	2.58	1.66				

NA - Not Available

TABLE 4-11. GLYCOL SOLVENTS

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Diethylene glycol	72	20		Petroleum solvent extraction	Solvents for oil and gas extraction	1.82		NA	26	Ethylene oxide	22, 29
				Solvent for printing ink	Solvents for printing operations	2.74					
				Solvent for wood stain	Solvents for printing inks, paint and allied products	1.90					
						1.90 mfg. paint and 2.82 painters	3.08				
Triethylene glycol	152	17	72	Natural gas dehydration							
			72	Plastics and surfactants							
			302	Polyurethane and unsaturated polyester							
			122	Textile agents							
			132	Triethylene glycol							
			242	Misc. and export							
					Solvent for printing inks	1.90		NA	27	Ethylene oxide, Diethylene glycol	29, 33
					Solvents for printing operations	2.74					
				UNEX extraction solvent & other	Solvents for printing inks	1.82					
				Solvent for water-borne surface coatings for flat wood paneling	Solvents for petroleum refining	2.50					
	172	19	302	Humectant							
			302	Natural gas dehydration							
			82	Polyester and polyurethane resins							
			122	Vinyl plasticizer							
			62	Export							
			MA		Chemical reaction solvent	2.24					
			MA	Lacquer solvent	Solvents for chemicals	1.90 mfg. paint and 2.82 painters	3.08				
			MA		Solvents for paint and allied products						

NA - Not Available

TABLE 4-12. PHENOL SOLVENTS

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Cresols	152	26		Magnetic wire enamel solvent	Solvents for coating magnetic wire	2.91		2	6	Petroleum isolate Phenol Naphthalene	21, 32
	152	26	Antioxidants								
	62	10	Cleaning and disinfecting compounds								
	62	10	Ore flotation								
	222	36	Phosphate esters								
Creosylic acids	152	26	Basins								
	102	19	Misc. uses								
	112	20	Exports								
	172	NA		Magnetic wire enamel solvent	Solvents for coating magnetic wire	2.91		2	6	Petroleum isolate	16, 32
	212	NA	Phosphate esters								
	172	NA	Phenolic resins								
	172	NA	Antioxidants								
	62	NA	Cleaning and disinfecting								
	62	NA	Ore flotation								
	172	NA	Miscellaneous								

NA - Not Available

TABLE 4-13. NITRATED AROMATIC SOLVENTS

Solvent Name	% Total Consumption (MM lb/yr)	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent (s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Nitrobenzene	1.5X	10		Solvent for cellulose ethers	Solvents for paints and allied products	1.90 mfg.	3.08	1	2	Benzene	13, 21
					Solvents for adhesives ^a	2.82 painters					
					Solvents for printing inks ^a	2.07 mfg.	2.07				
					Solvents for printing ^a	2.07 office					
					Solvents for printing ^a	1.90					
					Solvents for printing ^a	2.7%					
					Solvents for printing ^a						
					Solvents for printing ^a						
					Solvents for printing ^a						
					Solvents for printing ^a						
MA	1.5X	10		Solvent in petroleum refining	Solvents for printing ^a	1.82					
					Solvents for printing ^a						
					Solvents for printing ^a						
MA	97Z	650	Synthesis of aniline	Solvent in depolymerization of rubber for adhesives	Solvents for printing ^a	2.07 mfg.	2.07				
					Solvents for printing ^a	2.07 office					
97Z	97Z	650	Synthesis of aniline	Solvent in chlorination reactions	Solvents for printing ^a	2.24					
					Solvents for printing ^a						

MA - Not Available

^aThese are uses found for cellulose ethers. It is not clear whether nitrobenzene is used as a solvent for the ethers in these applications.

TABLE 4-14. SULFOXIDE SOLVENTS

Solvent Name	Σ Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent(s)	Reference
						Occupational	Consumer	Inhalation	Ingestion		
Dimethyl sulfoxide	NA	NA		Solvent for STX extraction from hydrocarbon feedstock	Solvents for petroleum refining	1.82		NA	20	Dimethyl sulfoxide	8, 19, 41
	NA	NA		Solvent for aromatics and heterocyclics	Solvents for chemicals	2.24					
	NA	NA		Solvent for high molecular weight materials							
	NA	NA		Solvent in mfg. polysulfone resins	Solvents for plastics & rubber materials and synthetics (not fabricated)	1.90					
	NA	NA		Analytical solvent	Solvents for research and development	2.75	2.92				
	NA	NA		Solvent in pharmaceutical products	Solvents for pharmaceuticals	2.58	1.66				

NA - Not Available

TABLE 4-15. THIONE SOLVENTS

Solvent Name	Σ Total Consumption (MM lb/yr)	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Marking		Chemical Parent(s)	Reference
						Occupational	Consumer	Inhalation	Ingestion		
Carbon disulfide	<215	<170		Solvents for waxes, oils, sulfur, and sulfur compounds	Solvents for chemicals	2.74		5	MA	Methane	29
	392	310	Intermediate in rayon mfg.								
	252	200	Intermediate in carbon tetrachloride mfg.								
	142	110	Colloidal mfg.								
	MA	MA	Other chemical production								

MA - Not Available

TABLE 4-16. HETEROCYCLIC SOLVENTS

Solvent Name	2 Total Consumption (MM lb/yr)	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent (s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Pyridine		2		Solvent, primarily in drug mfg.	2.58		1.66	2	4	Acetaldehyde Ammonia Coal tar isolate	29
		2	Pharmaceuticals								
		1	Production								
		1	Vehicle mfg. Piperidine mfg.								

TABLE 4-17. ESTER SOLVENTS

Solvent Name	Total Consumption (100 lb/yr)	Annual Consumption (100 lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent (s)	References
						Occupational	Consumer	Inhalation	Ingestion		
Amyl acetate	MA	MA		Nitrocellulose lacquer solvent Solvent for surface coating of flat wood paneling Paint, varnish and lacquer solvent Solvent for dry-cleaning preparations Phosphor solvent in fluorescent lamps Solvent for pen-cillin extractions Solvent for production of artificial leather Solvent for nail polish Solvent for photographic film Wax remover Smokeless powder solvent Solvent for airplane dope Solvent for water-proof coatings	Solvents for paint and allied products Solvents for roll coating Solvents for laundry and drycleaning Solvents for fluorescent lamps Solvents for pharmaceuticals Solvents for manicuring preparations Solvents for fabricating rubber and plastic products Solvents for chemicals Solvent for explosives	1.90 mfg. 2.82 painters 2.50	3.08	12	MA	Acetic acid Amyl alcohol	22, 24
MA	MA	MA				1.57 mfg. 2.74 manicurists 3.00	2.66				
MA	MA	MA				2.24 2.91					
MA	MA	MA				2.50	1.66				

TABLE 4-17. ESTER SOLVENTS (Continued)

Solvent Name	2 Total Consumption	Annual Consumption (MM lb/yr)	Non-Solvent Uses	Specific Solvent Uses	Solvent Use Category	Exposure Potential		Toxicity Ranking		Chemical Parent (c)	References
						Occupational	Consumer	Inhalation	Ingestion		
Ethyl acetate		13.5		Solvent for coatings: wood furniture & fixtures	Solvents for paint and allied products	1.90 mfg.	3.06	23	23	Acetic acid	21, 23, 29
		5.0		metal furniture & fixtures							
		5.4		adhesives							
		1.0		automotive topcoat							
		0.8		automotive primer							
				automotive after-market & misc.							
	702	2.0		trucks and buses							
		1.0		machinery & equipment							
		0.5		mint							
		1.0		paper, film, & foil factory finished building products							
		5.8		other product finishes							
		29		auto refinishing							
		55		Paint thinner & misc.							
	102	20		Solvent for plastics							
					Solvents for plastic and rubber materials (not fabricated)	1.90					
	172	34		Other solvent uses, including inks		1.90					
					Solvents for printing operations						
	32	6		Chemical synthesis		2.74					

NA - Not Available
 a - Primary solvent use

SOLVENT RANKINGSConsumption/Production

The information obtained about the solvents in this study was used to rank them in a number of ways. The solvents were ranked according to their total annual production amounts, by their total annual consumption amounts and according to the quantities consumed for solvent rather than non-solvent use. These rankings are shown in Tables 5-1, 5-2, and 5-3, respectively.

Quantitative consumption and production data were not available for all the solvents studied. Solvents not included are noted in each table.

The chemical parents of the solvents in this study were of two distinct types. Although the majority of solvents were derived from synthetically-produced petrochemicals, several (listed in Table 5-4) were produced from "parents" which were isolated from oil or natural gas liquids, petroleum reformate, or coal tar residues. Because annual production of these chemical parents could vary widely and was difficult to quantify, they were not ranked according to annual production.

Table 5-5 ranks the synthetically-produced chemical parents of the solvents studied according to annual production volume. In many cases, a number of solvents were derived from a common chemical parent. The solvents produced from each parent are also given in Table 5-5.

Exposure

An important part of assessing risk presented by chemicals used as solvents is a measure of their exposure to man and his environment. Although there are many exposure models to choose from, in this study the exposure rankings were based on a system devised by Auerbach Associates, "EPA Index of Exposure."

The Index of Exposure considers four major categories of exposure: mode of human exposure, mode of environmental exposure, amount of human exposure, and amount of environmental exposure. Exposure is considered for normal use in this system; exposure resulting from accidents is not included. The model is necessarily designed to be chemical independent. This means that oral, topical, and inhalation exposure are all considered of equal weight.

The Index of Exposure model does not include exposure to the general population from emissions or effluents from solvent production or use in industry. Thus, exposure of this nature is not included in the exposure estimates.

Numerical values are assigned within each exposure category or subcategory which indicate the relative degree of exposure in that category. The composite of the scores assigned in each category, the index of exposure, can then be used to rank the chemicals in question. More complete information concerning design and application of Auerbach's model is included in appendix A.

Auerbach Associates had completed exposure index scores for several of the applications for the solvents being

studied. However, for many of the uses of this group of solvents, Radian derived scores using Auerbach's model. All of the exposure index scores used in this study are included in Appendix B. Using these exposure index score cards, every use of the solvents on the list was assigned a score for occupational exposure and one for consumer exposure.

In ranking the solvents by exposure potential, it was necessary to make a decision as to how to reduce the group of exposure scores for each chemical to one score. The best method would be to weigh each solvent use category by the fractional amount of solvent used in that category, summing all of the resulting scores for each solvent. However, because the solvent use categories did not match the groups of uses for which consumption information was found, this method was not feasible.

It then became necessary to consider all of the exposure index scores for each solvent equally. Two composite scores for each solvent were devised: the maximum and the median. The maximum value was chosen to represent worst case exposure. To determine an intermediate case, the median was chosen as a representative exposure index score. These scores and the resulting rankings are shown in Tables 5-6, 5-7, 5-8, and 5-9. For several chemicals, no significant consumer applications were found: cresols, cresylic acids, and carbon disulfide.

Toxicity

It was difficult to rank the solvents according to their toxic effects because toxicological data were incomplete for some of the chemicals in the study. Only nonspecific, acute systemic toxicity was ranked because (1) data for local

human toxicity were incomplete or could not be obtained from readily-accessible sources; and (2) systemic toxicity is generally a more serious health effect than local toxicity.

For the purposes of this study, a toxic effect was defined as any noxious effect on the body - reversible or irreversible. In almost all cases, however, the effect was an acute one. Relatively little conclusive data regarding carcinogenicity, mutagenicity, or teratogenicity were readily available. Chemicals which are suspected or known carcinogens are listed in Table 5-10.

Although there are a number of ways by which an individual may be exposed to a toxic chemical, the three most important and most usually encountered routes are: oral, dermal, and respiratory. In industrial situations and in other practical applications of chemicals, exposure is usually either respiratory or dermal or a combination of the two. Non-accidental oral exposure to industrial chemicals occurs less often, usually through ingesting food or pharmaceuticals.

In considering ranking schemes, toxicological indices were chosen which are specific, uniform and for which toxicity data for the solvents were relatively complete. Six toxicity scores were not used because they were too general and incomplete.

The following indices were chosen:

(1) For Toxicity via the Inhalation Route:

TLV (Threshold Limit Value) - The level of contaminant considered safe for a workroom atmosphere, as established by the American Conference of Governmental Industrial Hygienists (ACGIH). Ten hours per day or 40 hours per week exposure is assumed.

(2) For Toxicity via the Oral Ingestion Route:

LD50 (oral, rat) - The calculated dose of a chemical substance which is expected to cause the death of 50 percent of an experimental population of rats as determined from exposure to the substance by the oral route.

(3) Relative Dermal Toxicities:

Relative toxicities via the dermal route were not performed. Estimates of relative toxicity via the dermal route are complicated by gross differences in percutaneous absorption rates. Attempts were made to locate percutaneous absorption data in the literature, but such data could only be found on three of the solvents. According to the ACGIH, significant additional exposure through the skin may be dangerous for those solvents marked with an asterisk in Table 5-11.

The primary difficulty in using TLV's involves the inherent differences in the workplace environment as compared to the ambient environment. The most obvious difference involves length and periodicity of exposure. Such standards are based on a 40 hour per week exposure rather than a continuous ambient exposure. Furthermore, they were not developed to protect the young or the elderly. In addition, general synergistic or antagonistic effects are not incorporated and they do not address bioaccumulations. Finally, many of these solvents do not have a TLV or NIOSH recommended standard. Although there is a model that can be used to translate LD50 data into TLV estimates for these missing values, this model has difficulties and is still in the development stage.

The main problems in using LD50 data are the difficulties inherent in extrapolating animal toxicity data to humans, arising out of differences in toxic response between animals and humans. In addition, there are experimental variation problems arising out of the fact that these studies are conducted at different laboratories. These difficulties are minimized in using data from LD50 (oral, rat) tests, because: (1) the methodology for such tests is generally uniform; (2) toxic effects in rats are generally accepted as indicative of potential human toxicity; and (3) LD50 tests use a more exact and quantifiable endpoint than do other rat studies.

Toxicity rankings for both inhalation and ingestion are shown in Tables 5-11 and 5-12. Raw data are also included in each table.

Solvent vapor pressures were compared to inhalation toxicity rankings, as tabulated in Table 5-13, and shown graphically in Figure 5-1. As the figure shows, a number of solvents

ranked low in toxicity are also high vapor pressure chemicals. This relationship suggests that, although their relative toxicity via inhalation is low, the inhalation dosage (and thus the risk) may be high because of their greater volatility.

Environmental Effect

It was not possible to rank each solvent according to its effect on the environment. However, a feasible ranking system was developed using the data available. An ordering plan was followed which resulted in the assignment of a digital ordering system for solvents with aquatic toxicity and biodegradability ratings. Other ecological factors could have been included but were not because data are incomplete in the readily-accessible literature. The derivation of these ordering numbers follows:

First Digit: The biodegradability (i.e., environmental persistence) rating

Second Digit: The lowest aquatic toxicity rating

The value of the second digit was assigned according to the following scheme:

<u>Aquatic Toxicity Rating</u>	<u>Digit Value</u>
Over 1000 ppm	0
100 ppm	3
10 ppm	6
1 ppm	9

The ordering plan described above was used to rank 11 solvents for which some environmental data were available. The example rankings are shown in Table 5-14.

Safety Factors

Explosive limits and flash points for the solvents are presented in Table 5-15. The information was found in handbooks and readily available references. Safety factors are an important consideration in assessing the risk presented by solvents to man and his environment.

TABLE 5-1. RANKING BY TOTAL ANNUAL PRODUCTION^a

Chemical Name	Ranking	Annual Production (MM lb)	(year)
Toluene	1	7730	1977
Ethyl benzene	2	7300	1977
Methanol	3	6460	1977
Xylenes	4	6050	1977
Acetone	5	2144	1977
Carbon disulfide	6	782	1974
Perchloroethylene	7	734	1974
Nitrobenzene	8	655	1975
Cyclohexanone	9	651	1974
1,1,1-Trichloroethane	10	620	1977
Methylene chloride	11	609	1974
n-Butyl alcohol	12	558	1974
Methyl ethyl ketone	13	506	1976
Trichloroethylene	14	388	1974
Chlorobenzene	15	329	1976
Diethylene glycol	16	309	1974
Trichlorofluorophethane	17	270	1975
Methyl isobutyl ketone	18	207	1974
Ethyl acetate	19	197	1974
Ethyl ether	20	176	1974
Isobutanol	21	175	1974
Ethylene glycol monoethyl ether	22	160	1974
Ethylene glycol monobutyl ether	23	144	1974
Triethylene glycol	24	110	1974
Cresols	25	91	1974
Cresylic acid	26	77	1974
1,1,2-Trichloro-1,2,2- trifluoroethane	27	62	1976
Diethylene glycol monobutyl ether	28	25	1975
Amyl acetates	29	9	1964
Pyridine	30	9	1970
o-Dichlorobenzene	31	0.1	1976

^aQuantitative production data were not available from readily-accessible sources for the following chemicals: chloronaphthalenes, N,N-dimethylformamide, dimethyl sulfoxide. Ranking included 31 chemicals.

TABLE 5-2. RANKING BY TOTAL ANNUAL CONSUMPTION^a

Chemical Name	Ranking	Annual Consumption (MM lb/yr)
Methanol	1	7000
Toluene	2	6700
Xylenes	3	5810
Ethyl benzene	4	5650
Acetone	5	1943
Carbon disulfide	6	790
Methylene chloride	7	706
Cyclohexanone	8	700
Nitrobenzene	9	670
Perchloroethylene	10	664
n-Butyl alcohol	11	560
1,1,1-Trichloroethane	12	520
Methyl ethyl ketone	13	516
Trichloroethylene	14	440
Chlorobenzene	15	385
Diethylene glycol	16	291
Methyl isobutyl ketone	17	195
Ethyl ether	18	180
Isobutanol	19	172
Trichlorofluoromethane	20	167
Ethylene glycol monoethyl ether	21	165
Ethyl acetate	22	160
Cresols & cresylic acid	23	155
Ethylene glycol monobutyl ether	24	111
Triethylene glycol	25	101
1,1,2-Trichloro-1,2,2-trifluoroethane	26	53
Diethylene glycol monobutyl ether	27	15
Pyridine	28	2

^aQuantitative consumption data were not available from readily-accessible sources for the following chemicals: amyl acetates, chloronaphthalenes, o-dichlorobenzene, N,N-dimethylformamide, dimethyl sulfoxide. Only 28 solvents were ranked.

TABLE 5-3. RANKING BY AMOUNT USED IN SOLVENT APPLICATIONS^a

Chemical Name	Ranking	Amount Used as Solvent (MM lb/yr)
Xylenes	1	1080
Methanol	2	700
Toluene	3	700
Perchloroethylene	4	564
Methylene chloride	5	470
Methyl ethyl ketone	6	446
Trichloroethylene	7	415
1,1,1-Trichloroethane	8	400
Acetone	9	190
Methyl isobutyl ketone	10	172
Chlorobenzene	11	170
Carbon disulfide	12	~170
Ethyl acetate	13	154
Ethyl benzene	14	120
Ethyl ether	14	120
n-Butyl alcohol	16	100
Ethylene glycol monobutyl ether	16	100
Ethylene glycol monoethyl ether	18	85
1,1,2-Trichloro-1,2,2-trifluoroethane	19	53
Isobutanol	20	41
Triethylene glycol	21	30
Dichlorobenzene	22	26
Cresols & cresylic acid ^b	23	26
Cyclohexanone	24	20
Diethylene glycol	24	20
Nitrobenzene	24	20
Trichlorofluoromethane	24	20
Diethylene glycol monobutyl ether	28	7
Pyridine	29	2

^aQuantitative consumption data were not available from readily-accessible sources for the following chemicals: amyl acetates, chloronaphthalenes, N,N-dimethylformamide, dimethyl sulfoxide. Only 29 solvents were ranked.

^bConsumption amounts for cresol and cresylic acid were combined.

TABLE 5-4. SOLVENTS DERIVED FROM NON-SYNTHETIC CHEMICAL PARENTS

Solvent	Source
Carbon disulfide	Methane
Cresols & cresylic acid ^a	Petroleum reformat
Methylene chloride ^a	Methane
Methyl ethyl ketone ^a	Butane
Methanol ^a	Methane Synthesis gas ^b
1,1,1-Trichloroethane	Ethane
Perchloroethylene	Paraffins (Ethane, Propane, Butane)
Xylenes	Petroleum reformat
Pyridine ^a	Coal tar residues

^aAre also produced from various synthetic industrial organic chemicals.

^bH₂+CO - produced from methane and refinery feedstocks.

TABLE 5-5. RANKING OF SOLVENT CHEMICAL PARENTS^{a,b}

Parent	Ranking	Amt. Produced (MM lb/yr)	Solvents Produced
Ethylene	1	24,650	n-Butyl alcohol Ethyl benzene Ethyl ether
Propylene	2	12,560	n-Butyl alcohol Isobutanol
Benzene	3	11,250	Chlorobenzene o-Dichlorobenzene Ethyl benzene Nitrobenzene
Ethylene dichloride	4	7,920	1,1,1-Trichloroethane Trichloroethylene Perchloroethylene
Methanol	5	6,460	Methylene chloride
Xylene	6	6,050	Ethyl benzene
Ethylene oxide	7	4,420	Diethylene glycol Diethylene glycol monobutyl ether Ethylene glycol monobutyl ether Ethylene glycol monoethyl ether Triethylene glycol
Ethylene glycol	8	3,470	Triethylene glycol
Acetic acid	9	2,800	Ethyl acetate
Cumene	10	2,640	Acetone
Phenol	11	2,380	Cresols & cresylic acid Cyclohexanone
Cyclohexane	12	2,240	Cyclohexanone
Acetone	13	2,144	Methyl isobutyl ketone
Isopropanol	14	1,870	Acetone

TABLE 5-5. RANKING OF SOLVENT CHEMICAL PARENTS (Continued)

Parent		Amt. Produced (MM lb/yr)	Solvents Produced
Ethanol	15	1,618	Ethylene glycol mono- ethyl ether Ethyl acetate
Acetaldehyde	16	1,100	Pyridine
Carbon tetrachloride	22	850	Trichlorofluoromethane
Perchloroethylene	23	657	1,1,2-Trichloro-1,2,2- trifluoroethane
Naphthalene	24	560	Chloronaphthalene
Butanol	25	558	Isobutanol
sec-Butyl alcohol	26	525	Methyl ethyl ketone
Acetylene	27	500	Trichloroethylene

^aRanking includes 27 chemicals.

^bQuantitative production data were not available from readily-accessible sources for dimethyl sulfide (parent of dimethyl sulfoxide) and amyl alcohols (from which amyl acetates are derived).

TABLE 5-6. EXPOSURE INDEX AND RANKING FOR CONSUMER APPLICATIONS USING THE MAXIMUM EXPOSURE SCORE

Solvent	Ranking	Maximum Exposure Index	Range of Exposure Indices
Ethyl benzene	1	3.33	2.92-3.33
Xylenes	1	3.33	1.66-3.33
Methyl isobutyl ketone	3	3.17	1.66-3.17
1,1,1-Trichloroethane	3	3.17	1.66-3.17
Chlorobenzene	3	3.17	3.08-3.17
Methylene chloride	6	3.08	1.50-3.08
1,1,2-trichloro-1,2,2-trifluoroethane	6	3.08	2.08-3.08
Trichlorofluoromethane	6	3.08	3.08
n-Butyl alcohol	6	3.08	1.66-3.08
Nitrobenzene	6	3.08	2.07-3.08
Amyl acetates	6	3.08	1.66-3.08
Diethylene glycol monobutyl ether	6	3.08	1.42-3.08
Ethyl acetate	6	3.08	3.08
Ethylene glycol monoethyl ether	6	3.08	1.66-3.08
Ethylene glycol monobutyl ether	6	3.08	1.16-3.08
Isobutanol	6	3.08	3.08
Methanol	6	3.08	1.66-3.08
o-Dichlorobenzene	6	3.08	1.66-3.08
N,N-Dimethylformamide	6	3.08	1.42-3.08
Acetone	6	3.08	1.66-3.08
Methyl ethyl ketone	6	3.08	1.66-3.08
Cyclohexanone	6	3.08	2.74-3.08
Toluene	6	3.08	2.07-3.08
Trichloroethylene	6	3.08	1.50-3.08
Perchloroethylene	6	3.08	2.08-3.08
Diethylene glycol	6	3.08	3.08
Triethylene glycol	6	3.08	3.08
Chloronaphthalenes	28	3.00	3.00
Dimethylsulfoxide	29	2.92	1.66-2.92
Pyridine	30	1.66	1.66
Ethyl ether	30	1.66	1.66

For the following chemicals, no significant consumer applications were found: cresols, cresylic acid, carbon disulfide.

TABLE 5-7. EXPOSURE INDEX AND RANKING FOR CONSUMER APPLICATIONS USING THE MEDIAN EXPOSURE SCORE

Solvent	Ranking	Maximum Exposure Index	Range of Exposure Indices
Ethyl benzene	1	3.12	2.92-3.33
Chlorobenzene	1	3.12	3.08-3.17
Xylenes	3	3.08	1.66-3.33
Trichlorofluoromethane	3	3.08	3.08
Ethyl acetate	3	3.08	3.08
Isobutanol	3	3.08	3.08
o-Dichlorobenzene	3	3.08	1.66-3.08
Cyclohexanone	3	3.08	2.74-3.08
Ethylene glycol monobutyl ether	3	3.08	1.16-3.08
Diethylene glycol	3	3.08	3.08
Triethylene glycol	3	3.08	3.08
N,N-Dimethylformamide	12	3.00	1.42-3.08
Chloronaphthalenes	12	3.00	3.00
Methyl isobutyl ketone	14	2.92	1.66-3.17
Methanol	15	2.76	1.66-3.08
Perchloroethylene	16	2.74	2.08-3.08
Ethylene glycol monoethyl ether	17	2.70	1.66-3.08
1,1,1-Trichloroethane	18	2.66	1.66-3.17
1,1,2-Trichloro-1,2,2-trifluoroethane	19	2.58	2.08-3.08
Toluene	19	2.58	2.07-3.08
Diethylene glycol monobutyl ether	21	2.54	1.42-3.08
Methylene chloride	22	2.37	1.50-3.08
n-Butyl alcohol	22	2.37	1.66-3.08
Amyl acetates	22	2.37	1.66-3.08
Dimethyl sulfoxide	25	2.29	1.66-2.92
Trichloroethylene	26	2.08	1.50-3.08
Nitrobenzene	27	2.07	2.07-3.08
Acetone	27	2.07	1.66-3.08
Methyl ethyl ketone	27	2.07	1.66-3.08
Pyridine	30	1.66	1.66
Ethyl ether	30	1.66	1.66

For the following chemicals, no significant consumer applications were found: cresols, cresylic acid, carbon disulfide.

TABLE 5-8. EXPOSURE INDEX AND RANKING FOR OCCUPATIONAL APPLICATIONS USING THE MAXIMUM EXPOSURE SCORE

Solvent	Ranking	High Value	Range of Exposure Indices
Ethyl benzene	1	3.25	1.90-3.25
Xylenes	1	3.25	1.90-3.25
Methylisobutyl ketone	1	3.25	1.90-3.25
Chlorobenzene	1	3.25	2.41-3.25
1,1,1-Trichloroethane	1	3.25	1.90-3.25
Ethylene glycol monobutyl ether	6	3.16	1.90-3.16
Perchloroethylene	6	3.16	1.90-3.16
Trichloroethylene	6	3.16	1.90-3.16
Cyclohexanone	6	3.16	1.90-3.16
Chloronaphthalenes	6	3.16	1.90-3.16
N,N-Dimethylformamide	6	3.16	1.90-3.16
Isobutanol	6	3.16	1.90-3.16
Ethylene glycol monoethyl ether	6	3.16	1.90-3.16
Diethylene glycol monobutyl ether	6	3.16	1.90-3.16
Trichlorofluoromethane	6	3.16	2.83-3.16
1,1,2-Trichloro-1,2,2-trifluoroethane	6	3.16	2.41-3.16
Methylene chloride	6	3.16	1.90-3.16
o-Dichlorobenzene	6	3.16	2.24-3.16
Amyl acetates	19	3.00	1.57-3.00
Acetone	20	2.91	1.75-2.91
Cresols	20	2.91	2.91
Cresylic acids	20	2.91	2.91
Nitrobenzene	23	2.82	1.82-2.82
Ethyl acetate	23	2.82	1.90-2.82
Methanol	23	2.82	1.82-2.82
n-Butyl alcohol	23	2.82	1.90-2.82
Toluene	23	2.82	1.90-2.82
Methyl ethyl ketone	23	2.82	1.82-2.82
Diethylene glycol	23	2.82	1.82-2.82
Triethylene glycol	23	2.82	1.82-2.82
Dimethyl sulfoxide	31	2.75	1.82-2.75
Pyridine	32	2.58	2.58
Ethyl ether	32	2.58	2.24-2.58
Carbon disulfide	34	2.24	2.24

TABLE 5-9. EXPOSURE INDEX AND RANKING FOR OCCUPATIONAL APPLICATIONS USING MEDIAN EXPOSURE SCORE

Solvent	Ranking	Median Exposure Ranking	Range
Trichlorofluoromethane	1	3.00	2.83-3.16
Chlorobenzene	1	3.00	2.41-3.25
Isobutanol	3	2.95	1.90-3.16
1,1,2-Trichloro-1,2,2-trifluoroethane	4	2.92	2.41-3.16
Cresols	5	2.91	2.91
Cresylic acids	5	2.91	2.91
Ethylene glycol monobutyl ether	7	2.82	1.90-3.16
Diethylene glycol monobutyl ether	8	2.78	1.90-3.16
o-Dichlorobenzene	9	2.74	2.24-3.16
Cyclohexanone	9	2.74	1.90-3.16
Methylene chloride	11	2.70	1.90-3.16
Ethylbenzene	12	2.67	1.90-3.25
Perchloroethylene	13	2.66	1.90-3.16
Xylenes	14	2.62	1.90-3.25
Chloronaphthalenes	14	2.62	1.90-3.16
Ethylene glycol monoethyl ether	16	2.58	1.90-3.16
Pyridine	16	2.58	2.58
Trichloroethylene	16	2.58	1.90-3.16
n-Butyl alcohol	19	2.54	1.90-2.82
Ethyl acetate	20	2.52	1.90-2.82
1,1,1-Trichloroethane	21	2.50	1.90-3.25
Amyl acetates	21	2.50	1.57-3.00
Methyl isobutyl ketone	23	2.46	1.90-3.25
N,N-Dimethylformamide	24	2.41	1.90-3.16
Toluene	25	2.28	1.90-2.92
Dimethyl sulfoxide	26	2.24	1.82-2.75
Methyl ethyl ketone	26	2.24	1.82-2.82
Carbon disulfide	26	2.24	2.24
Ethyl ether	26	2.24	2.24-2.58
Acetone	26	2.24	1.75-2.91
Methanol	26	2.24	1.82-2.82
Triethylene glycol	26	2.24	1.82-2.82
Nitrobenzene	33	2.07	1.82-2.82
Diethylene glycol	34	1.90	1.82-2.82

TABLE 5-10. CHEMICALS KNOWN OR SUSPECTED AS CARCINOGENS

Chemical Name	Basis for Inclusion
Nitrobenzene	Structurally related to carcinogenic aryl amines. EPA priority pollutant. ^a
Trichlorofluoromethane	Structurally related to carcinogenic carbon tetrachloride. EPA priority pollutant. ^a
Ethyl benzene	Produced tumors in rats via ingestion. EPA priority pollutant. ^a
Trichloroethylene	Carcinogenic in mice. Structurally related to vinyl chloride, a known carcinogen. EPA priority pollutant. ^a
Perchloroethylene	EPA priority pollutant. ^a Strong suspicion of carcinogenicity because of its chemical structure.
1,1,1-Trichloroethane	Structurally related to chloroform, a known carcinogen. EPA priority pollutant. ^a
Toluene	Structurally related to benzene, a suspected human carcinogen. EPA priority pollutant. ^a
o-Dichlorobenzene	Structurally related to DDT, which is carcinogenic in mice. EPA priority pollutant. ^a
Chlorobenzene	Structurally related to DDT, which is carcinogenic in mice. EPA priority pollutant. ^a
Diethylene glycol	Suspected carcinogen in rats via ingestion.

^a These were named Priority Pollutants in the Consent Decree resulting from NRDC vs. EPA. The Effluent Guidelines Division of EPA is now in the process of promulgating standards.

TABLE 5-11. TOXICITY RANKINGS VIA INHALATION ROUTE^a

Chemical	TWA TLV ^b Ranking	Reciprocal of TWA TLV x 1000	TWA TLV (Adopted) (ppm)
Nitrobenzene*	1	1000	1
Cresols/cresylic acid	2	200	5
Pyridine*	2	200	5
N,N-Dimethylformamide	4	100	10
Carbon disulfide*	5	50	20
n-Butyl alcohol*	6	20	50
Cyclohexanone	6	20	50
o-Dichlorobenzene	6	20	50
Ethylene glycol monobutyl ether*	6	20	50
Isobutanol	6	20	50
Chlorobenzene	11	13	75
Amyl acetate	12	10	100
Ethyl benzene	12	10	100
Methyl isobutyl ketone*	12	10	100
Perchloroethylene*	12	10	100
Toluene*	12	10	100
Trichloroethylene	12	10	100
Xylenes (mixed)	12	10	100
Ethylene glycol monoethyl ether*	19	5	200
Methanol*	19	5	200
Methylene chloride	19	5	200
Methyl ethyl ketone	19	5	200
1,1,1-Trichloroethane	22	3	350
Ethyl acetate	23	3	400
Ethyl ether	23	3	400
Acetone	25	1	1000
Trichlorofluoromethane	25	1	1000
1,1,2-Trichloro-	25	1	1000
1,2,2-trifluoroethane			

^a Only 30 solvents were ranked. Data were not readily available for dimethyl sulfoxide, diethylene glycol, diethylene glycol monobutyl ether, triethylene glycol, chloronaphthalene.

^b TWA TLV = Time-weighted Average Threshold Limit Value - the time-weighted average concentration for a normal 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

*Significant additional exposure through the skin may be dangerous for these solvents.

TABLE 5-12. TOXICITY RANKINGS VIA INGESTION^a

Chemical	LD50 Ranking	Reciprocal of LD50 x 10,000	LD50 (oral, rat) (mg/Kg.)
o-Dichlorobenzene	1	20	500
Nitrobenzene	2	16	640
n-Butyl alcohol	3	13	790
Pyridine	4	11	891
Methylene chloride	5	11	945
Cresols/cresylic acid	6	7	1454
Ethylene glycol monobutyl ether	7	7	1480
Chloronaphthalene	8	6	1540
Cyclohexanone	9	6	1620
Ethyl ether	10	6	1700
Methyl isobutyl ketone	11	5	2080
Isobutanol	12	4	2460
N,N-Dimethylformamide	13	4	2800
Chlorobenzene	14	3	2910
Ethylene glycol monoethyl ether	15	3	3000
Methyl ethyl ketone	16	3	3400
Ethyl benzene	17	3	3500
Trichloroethylene	18	2	4920
Toluene	19	2	5000
Dimethyl sulfoxide	20	2	5360
Diethylene glycol monobutyl ether	21	2	6560
Acetone	22	1	9750
Ethyl acetate	23	1	11000
Methanol	24	1	13000
1,1,1-Trichloroethane	25	1	14300
Diethylene glycol	26	1	14800
Triethylene glycol	27	1	17000

^aRanking includes 28 solvents. Insufficient data were available for amyl acetates, carbon disulfide, trichlorofluoromethane, 1,1,2-trichloro-, 1,2,2-trifluoroethane, xylenes, perchloroethylene.

TABLE 5-13. COMPARISON OF TOXICITY VS. VAPOR PRESSURE

Solvent	Reciprocal of TWA TLVx1000	Toxicity Ranking (inhalation)	Vapor Pressure Ranking	Vapor Pressure (mmHg)	Temperature (°C)
Nitrobenzene	1000	1	29	0.15	20
Cresols/cresylic acid	200	2	28	0.24	20
Pyridine	200	2	12	14	20
N,N-Dimethylformamide	100	4	23	2.7	20
Carbon disulfide	50	5	5	260	20
n-Butyl alcohol	20	6	20	4.4	20
Cyclohexanone	20	6	21	4	20
o-Dichlorobenzene	20	6	24	1	20
Ethylene glycol monobutyl ether	20	6	26	0.6	20
Isobutanol	20	6	14	10	20
Chlorobenzene	13	11	15	8.8	20
Amyl acetate	10	12	17	6	20
Ethyl benzene	10	12	16	7	20
Methyl isobutyl ketone	10	12	17	6	20
Perchloroethylene	10	12	12	14	20
Toluene	10	12	11	22	20
Trichloroethylene	10	12	10	60	20
Xylenes (mixed)	10	12	17	6	20
Ethylene glycol monoethyl ether	5	19	22	3.8	20
Methanol	5	19	7	92	20
Methylene chloride	5	19	2	349	20
Methyl ethyl ketone	5	19	8	77.5	20
1,1,1-Trichloroethane	3	22	6	100	20
Ethyl acetate	3	22	9	72.8	20
Ethyl ether	3	22	1	442	20
Acetone	1	25	4	270	30
Trichlorofluoromethane	1	25	25	0.904	20
1,1,2-Trichloro-1,2,2-trifluoroethane	1	25	3	270	20
Dimethyl sulfoxide	NA	NA	27	0.42	20
Diethylene glycol	NA	NA	31	<0.01	20
Diethylene glycol monobutyl ether	NA	NA	30	0.02	20
Chloronaphthalenes	NA	NA	33	<1	86.5
Triethylene glycol	NA	NA	32	0.001	20

NA- Not Available

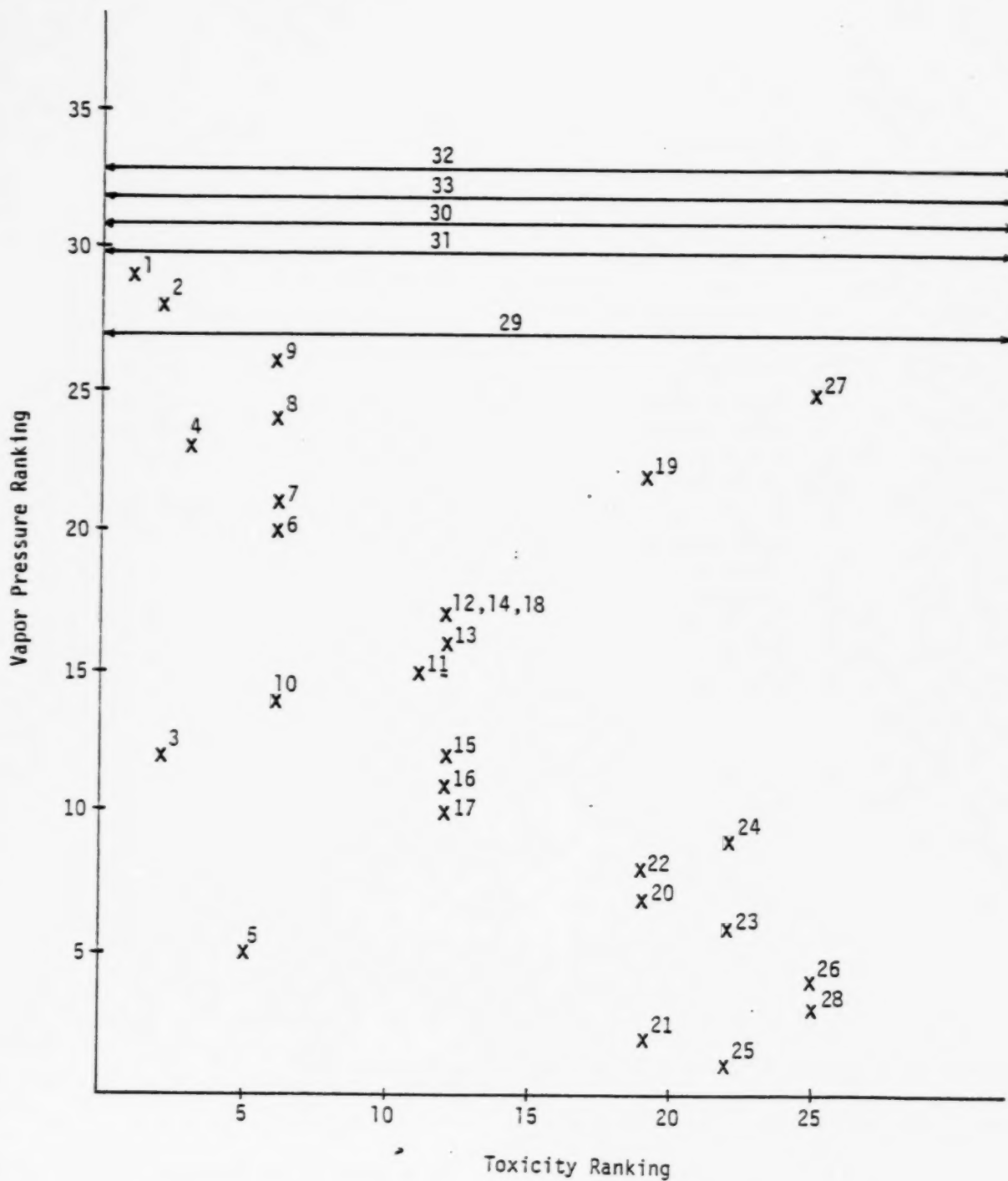


FIGURE 5-1. COMPARISON OF TOXICITY AND VAPOR PRESSURE RANKINGS (page 1 of 2)

Figure 5-1. (Continued)

1. Nitrobenzene
2. Cresols/cresylic acid
3. Pyridine
4. N,N-Dimethylformamide
5. Carbon disulfide
6. n-Butyl alcohol
7. Cyclohexanone
8. o-Dichlorobenzene
9. Ethylene glycol monobutyl ether
10. Isobutanol
11. Chlorobenzene
12. Amyl acetate
13. Ethyl benzene
14. Methyl isobutyl ketone
15. Perchloroethylene
16. Toluene
17. Trichloroethylene
18. Xylenes (mixed)
19. Ethylene glycol monoethyl ether
20. Methanol
21. Methylene chloride
22. Methyl ethyl ketone
23. 1,1,1-Trichloroethane
24. Ethyl acetate
25. Ethyl ether
26. Acetone
27. Trichlorofluoromethane
28. 1,1,2-Trichloro-1,2,2-trifluoromethane
29. Dimethyl sulfoxide
30. Diethylene glycol
31. Diethylene glycol monobutyl ether
32. Chloronaphthalenes
33. Triethylene glycol

FIGURE 5-1. COMPARISON OF TOXICITY AND VAPOR PRESSURE RANKINGS (Page 2 of 2)

TABLE 5-14. RANKING OF SOLVENTS BY ENVIRONMENTAL EFFECT

Chemical	Ecology Score Ranking	Ecology Score
1,1,1-Trichloroethane	1	56
Chlorobenzene	2	48
Nitrobenzene	3	46
Methylene chloride	4	44
Cresols	5	38
Ethylbenzene	6	36
Toluene	6	36
Xylenes (mixed)	6	36
Methanol	9	20
Acetone	10	10
Methyl ethyl ketone	10	10

TABLE 5-15. PARAMETERS RELATED TO SAFETY IN
USE OF SOLVENTS STUDIED^a

Chemical	Explosive Limits in Air (volume %)	Flash Point (°C)
Acetone	2.15-13.0	(-)16
Amyl acetates	1.1-7.5	25
n-Butyl alcohol	1.45-11.25	46
Carbon disulfide	1-50	(-)30
Chlorobenzene	1.3-7.1	29
Chloronaphthalene		132
Cresols/cresylic acid		81
Cyclohexanone	1.1- b	130
o-Dichlorobenzene	2.2-9.2	68
Diethylene glycol		143
Diethylene glycol monobutyl ether		110
N,N-Dimethylformamide	2.2-15.2	67
Dimethylsulfoxide		95
Ethyl acetate	2.2-11.4	(-) 5-26
Ethylbenzene		15
Ethylene glycol monobutyl ether		74
Ethylene glycol monoethyl ether	2.6-15.7	46
Ethyl ether	1.85-48	(-)45
Isobutanol	1.68-10.9	29
Methanol	6-36.5	12
Methylene chloride	15.5-66.4 ^d	15
Methyl ethyl ketone	1.8-10	22
Methyl isobutyl ketone		25
Nitrobenzene	1.8- b	16
Perchloroethylene	None	20
Pyridine	1.8-12.4	88
Toluene	1.3-6.75	4
Trichloroethane		Nonflammable
Trichloroethylene		Nonflammable
Trichlorofluoromethane		Nonflammable

TABLE 5-15. PARAMETERS RELATED TO SAFETY IN USE OF
SOLVENTS STUDIED (Continued)

Chemical	Explosive Limits in Air (volume %)	Flash Point (°C)
Triethylene glycol		
1,1,2-Trichloro-1,2,2- trifluoroethane		330 OC ^c
Xylenes	1.1-6.6	27-31

^aReferences: 26, 22, 42

^bNo upper limit was given in the references consulted

^cOC: tag open cup

CC: closed cup

^dIn oxygen

To adequately assess the risk posed by chemicals, the potential for exposure to man must be compared to toxicity. In the course of this study it became apparent that the modes of exposure of importance were topical and inhalation. The corresponding toxicity values are TLV's and some dermal toxicity parameters. Dermal toxicity data were scarce as discussed in Section 5.0, so that comparisons of exposure with this type of toxicity data would yield little information. For this reason, the comparisons included in this section are limited to comparisons of exposure to inhalation toxicity parameters: TLV's.

The numerical method chosen to relate toxicity rankings to exposure rankings was addition of the two rankings. The maximum was chosen to give a worst case analysis. The median was chosen as a statistically acceptable method for treating the values. Applying this method results in four sets of sums:

- Median occupational ranking and inhalation toxicity ranking
- Maximum occupational ranking and inhalation toxicity ranking
- Median consumer ranking and inhalation toxicity ranking
- Maximum consumer ranking and inhalation toxicity ranking

These sums are shown in Tables 6-1 and 6-2. Rankings and sums are shown graphically in Figures 6-1 through 6-4. Sums are

missing for those solvents for which TLV's were not available: chloronaphthalene, diethylene glycol, diethylene glycol monobutyl ether, and dimethyl sulfoxide.

Arbitrarily taking fifteen as the cut off point, the four sets of sums were examined and those solvents having sums equal to 15 or less were listed in Table 6-3. These solvents are considered to present the largest risk and are recommended for further study.

TABLE 6-1. COMPARISON OF INHALATION TOXICITY AND EXPOSURE RANKINGS USING MEDIAN VALUES

Solvent	Median			Inhalation Toxicity Ranking	Sum of Exposure and Toxicity Rankings	
	Occupational	Exposure Ranking	Consumer		Occupational	Consumer
Acetone	26	27	25	51	52	
Amyl acetates	21	22	12	33	34	
n-Butyl alcohol	19	22	6	25	28	
Carbon disulfide	26	a	5	31	a	
Chlorobenzene	1	1	11	12	12	
Chloronaphthalenes	14	12	N.D.	N.D.	N.D.	
Cresols/cresylic acid	5	a	2	7	a	
Cyclohexanone	9	3	6	15	9	
o-Dichlorobenzene	9	3	6	15	9	
Diethylene glycol	34	3	N.D.	N.D.	N.D.	
Diethylene glycol monobutyl ether	8	21	N.D.	N.D.	N.D.	
N,N-Dimethylformamide	24	12	4	28	16	
Dimethyl sulfoxide	26	25	N.D.	N.D.	N.D.	
Ethyl acetate	20	3	23	43	26	
Ethyl benzene	12	1	12	24	13	
Ethylene glycol monobutyl ether	7	3	6	13	9	
Ethylene glycol monoethyl ether	16	17	19	35	36	
Ethyl ether	26	30	23	49	53	
Isobutanol	3	3	6	9	9	
Methanol	26	15	19	45	34	
Methylene chloride	11	22	19	30	41	
Methyl ethyl ketone	26	27	19	45	46	
Methyl isobutyl ketone	23	14	12	35	26	
Nitrobenzene	33	27	1	34	28	
Perchloroethylene	13	16	12	25	28	
Pyridine	16	30	2	18	32	
Toluene	25	19	12	37	31	
1,1,1-Trichloroethane	21	18	22	43	40	

TABLE 6-1. COMPARISON OF INHALATION TOXICITY AND EXPOSURE RANKINGS USING MEDIAN VALUES (Continued)

Solvent	Median Exposure Ranking		Inhalation Toxicity Ranking	Sum of Exposure and Toxicity Rankings	
	Occupational	Consumer		Occupational	Consumer
Trichloroethylene	16	26	12	28	38
Trichlorofluoromethane	1	3	25	26	28
Triethylene glycol	26	3	N.D.	N.D.	N.D.
1,1,2-Trichloro-1,2,2-trifluoromethane	4	19	25	29	44
Xylenes	14	3	12	26	15

N.D. - No Data

^aFor these chemicals, no significant consumer applications were found.

TABLE 6-2. COMPARISON OF INHALATION TOXICITY AND EXPOSURE RANKINGS USING MAXIMUM VALUES

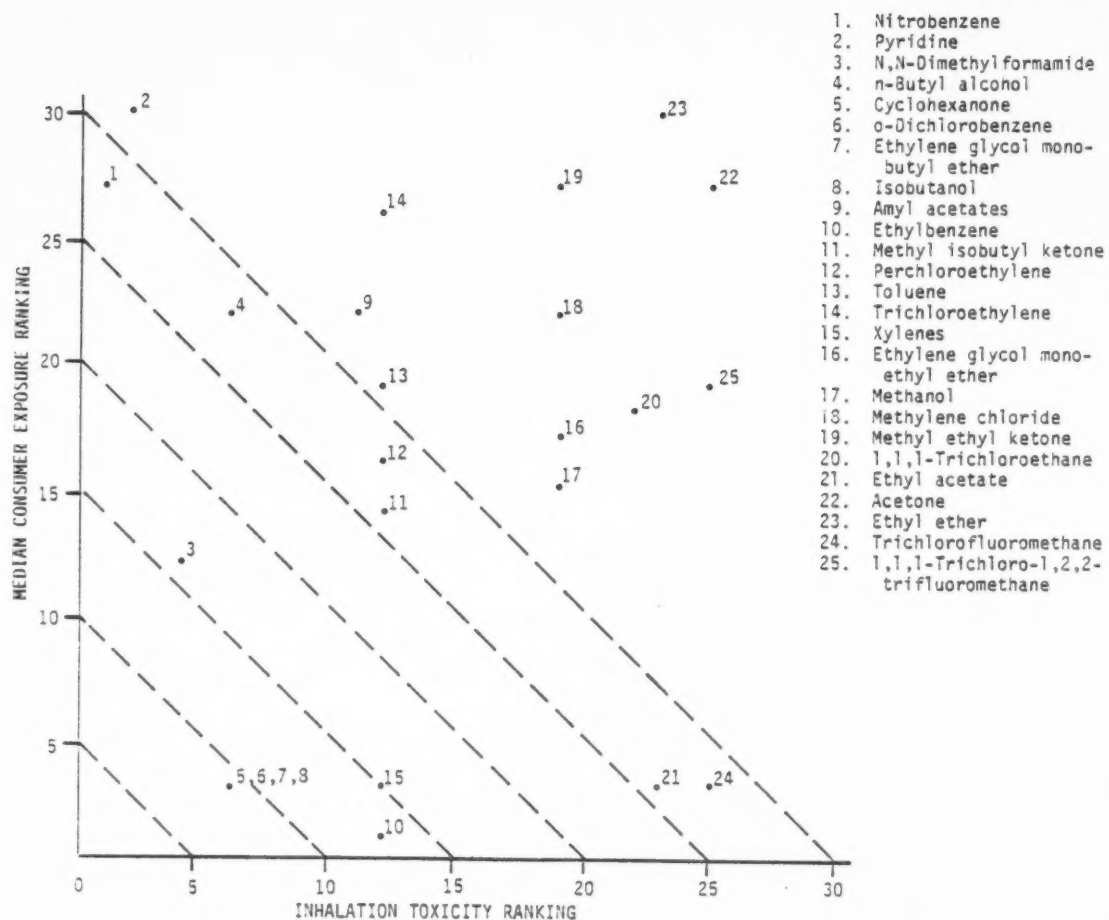
Solvent	Maximum Exposure Ranking Occupational	Maximum Exposure Ranking Consumer	Inhalation Toxicity Ranking	Sum of Exposure and Toxicity Rankings Occupational	Sum of Exposure and Toxicity Rankings Consumer
Acetone	20	6	25	45	31
Amyl acetates	19	6	12	31	18
n-Butyl alcohol	23	6	6	29	12
Carbon disulfide	34	a	5	39	a
Chlorobenzene	1	3	11	12	14
Chloronaphthalenes	6	28	N.D.	N.D.	N.D.
Cresols/cresylic acid	20	a	2	22	a
Cyclohexanone	6	6	6	12	12
o-Dichlorobenzene	6	6	6	12	12
Diethylene glycol	23	6	N.D.	N.D.	a
Diethylene glycol monobutyl ether	6	6	N.D.	N.D.	N.D.
N,N-Dimethylformamide	6	6	4	10	10
Dimethyl sulfoxide	31	29	N.D.	N.D.	N.D.
Ethyl acetate	23	6	23	46	29
Ethylbenzene	1	1	12	13	13
Ethylene glycol monobutyl ether	6	6	6	12	12
Ethylene glycol monoethyl ether	6	6	19	25	25
Ethyl ether	32	30	23	55	53
Isobutanol	6	6	6	12	12
Methanol	23	6	9	42	25
Methylene chloride	6	6	19	25	25
Methyl ethyl ketone	23	6	9	42	25
Methyl isobutyl ketone	1	3	12	13	15
Nitrobenzene	23	6	1	24	7
Perchloroethylene	6	6	12	18	18
Pyridine	32	30	2	34	32
Toluene	23	6	12	35	18
1,1,1-Trichloroethane	1	3	22	23	25
Trichloroethylene	6	6	12	18	18

TABLE 6-2. COMPARISON OF INHALATION TOXICITY AND EXPOSURE RANKINGS USING MAXIMUM VALUES (Continued)

Solvent	Maximum Exposure Ranking		Inhalation Toxicity Ranking	Sum of Exposure and Toxicity Rankings	
	Occupational	Consumer		Occupational	Consumer
Trichlorofluoromethane	6	6	25	31	31
Triethylene glycol	23	6	N.D.	N.D.	a
1,1,2-Trichloro-1,2,2-trifluoromethane	6	6	25	31	31
Xylenes	1	1	12	13	13

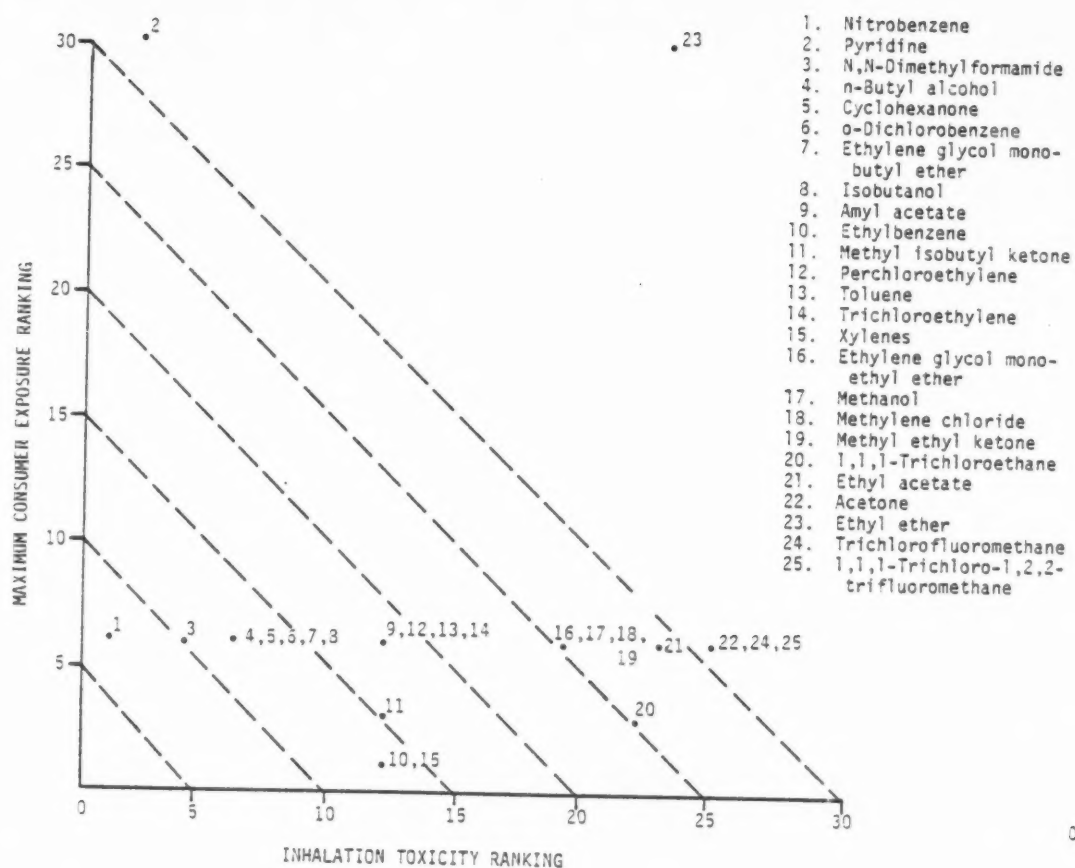
N.D. - No Data

^aFor these chemicals, no significant consumer applications were found.



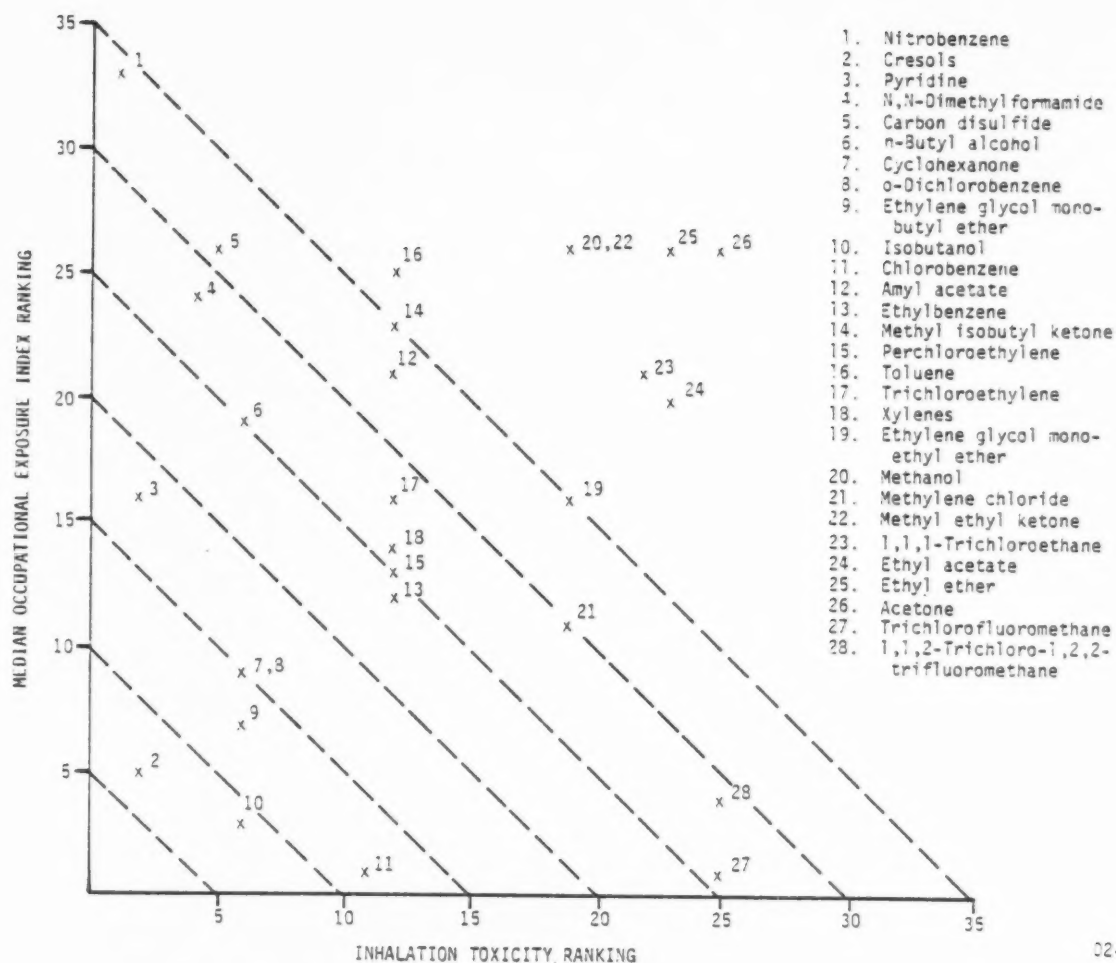
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FIGURE 6-1. COMPARISON OF INHALATION TOXICITY AND MEDIAN EXPOSURE RANKING FOR CONSUMER USE SOLVENTS



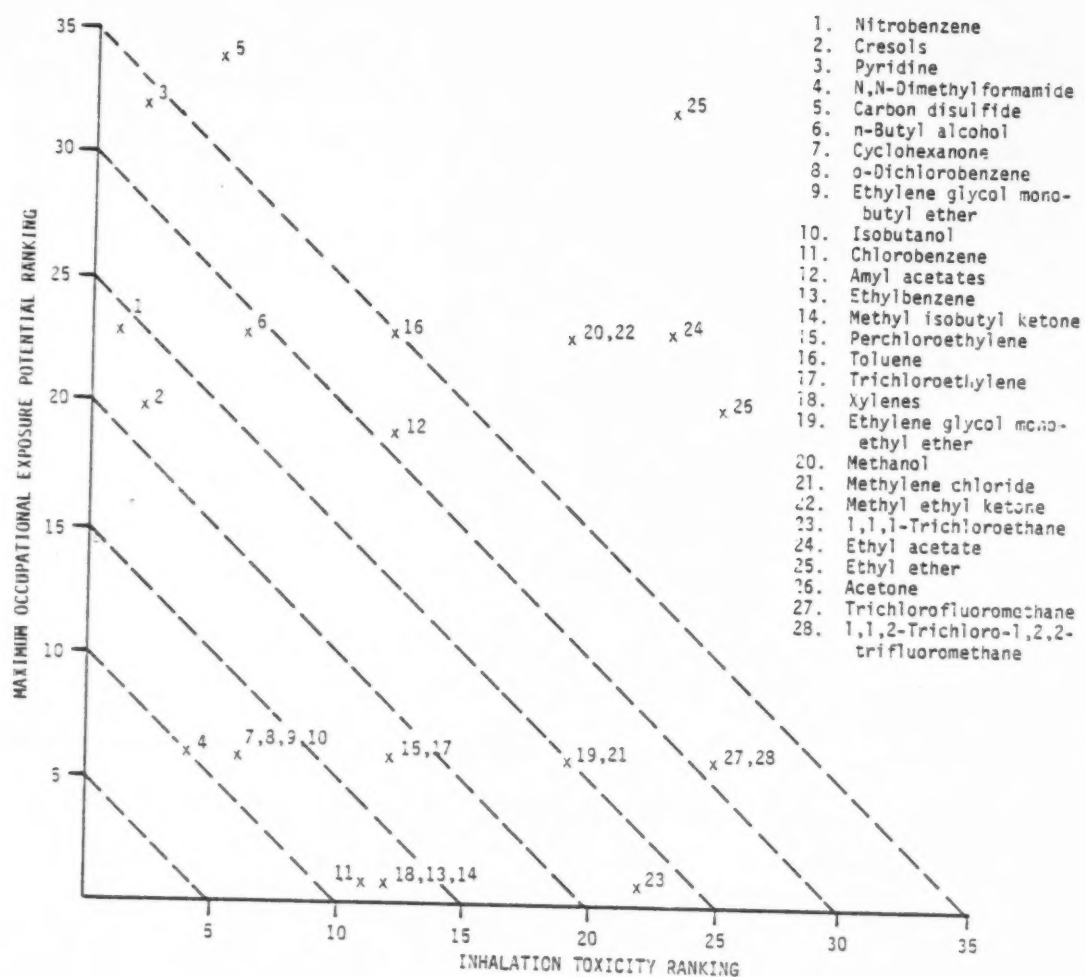
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FIGURE 6-2. COMPARISON OF INHALATION TOXICITY AND MAXIMUM EXPOSURE RANKING FOR CONSUMER USE OF SOLVENTS



02-5382-1

FIGURE 6-3. COMPARISON OF INHALATION TOXICITY AND MEDIAN EXPOSURE RANKINGS FOR OCCUPATIONAL USE OF SOLVENTS



02-536

FIGURE 6-4. COMPARISON OF INHALATION TOXICITY AND MEDIAN EXPOSURE RANKINGS FOR OCCUPATIONAL USE OF SOLVENTS

TABLE 6-3. SOLVENTS REPRESENTING THE GREATEST RISK

Solvent	Sums of Exposure and Toxicity Rankings			
	Consumer		Occupational	
	Max.	Med.	Max.	Med.
n-Butyl alcohol	<u>12</u>	28	29	25
Chlorobenzene	<u>14</u>	<u>12</u>	<u>12</u>	<u>12</u>
o-Dichlorobenzene	<u>12</u>	<u>9</u>	<u>12</u>	<u>15</u>
N,N-Dimethylformamide	<u>0</u>	16	<u>10</u>	28
Ethylbenzene	<u>13</u>	<u>13</u>	<u>13</u>	24
Isobutanol	<u>12</u>	<u>9</u>	<u>12</u>	<u>9</u>
Xylenes	<u>13</u>	<u>15</u>	<u>13</u>	26
Cyclohexanone	<u>12</u>	<u>9</u>	<u>12</u>	<u>15</u>
Ethylene glycol mono-butyl ether	<u>12</u>	<u>9</u>	<u>12</u>	<u>13</u>
Methyl isobutyl ketone	<u>15</u>	26	<u>13</u>	35
Nitrobenzene	<u>7</u>	28	24	34
Cresols/cresylic acid	a	a	22	<u>7</u>

^aFor this chemical, no significant consumer use was found.

REFERENCES

1. Abrams, E. F., et al., Identification of Organic Compounds in Effluents from Industrial Sources, EPA 560/3-75-002, PB 241 641, Springfield, Virginia, Versar, Inc., April 1975.
2. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH, Cincinnati, Ohio, 1978.
3. Austin, G. T. "The Industrially Significant Organic Chemicals, Parts 1-9," Chemical Engineering, 1974.
4. Beyer, W. L., Auerbach Associates, Inc., Letter to Mr. Ernest Stalder, U.S. Environmental Protection Agency, November 16, 1977.
5. Boscak, V., et al., Assessment of the Environmental Effect of the Pharmaceutical Industry Draft Final Report, EPA Contract No. 68-02-2510, Wethersfield, Connecticut, TRC - The Research Corporation of New England, December 1978.
6. Browning, E., Toxicity and Metabolism of Industrial Solvents, New York, New York, Elsevier Publishing Company, 1965.
7. Cleland, J. G. and G. L. Kingsbury, Multimedia Environmental Goals for Environmental Assessment, Vol. I, EPA 600/7-77-136a, Research Triangle Park, North Carolina, Research Triangle Institute, 1977.

8. Considine, D. M. ed. Chemical and Process Technology Encyclopedia, New York, McGraw-Hill Book Company, 1974.
9. E. I. DuPont de Nemours and Company, Freon Products Division, Petrochemical Department, Information submitted as requested by the U.S. Environmental Protection Agency, Wilmington, Delaware, March 15, 1978.
10. Dylewski, S. W., Emission Control Options for the Synthetic Organic Chemicals Manufacturing Industry: Chlorobenzenes Product Draft Report, EPA Contract 68-02-2577, Knoxville, Tennessee, Hydrosience, Inc., August 1978.
11. Fairchild, E. J., R. J. Lewis, and R. L. Tatken, eds., Registry of Toxic Effects of Chemical Substances, Vols. I and II, 1977 ed., Cincinnati, Ohio, National Institute for Occupational Safety and Health, September 1977.
12. Hatch, Lewis F., and Sami Mater, "From Hydrocarbons to Petrochemicals," Hydrocarbon Processing, Gulf Processing Company, September 1977-January 1979.
13. Hawley, G. G., rev., Condensed Chemical Dictionary, 8th ed. New York, New York, Van Nostrand Rheinhold Company, 1971.
14. Kavalier, A. R., ed., Chemical Marketing Reporter, Vol. 212, No. 24, New York, New York, Schnell Publishing Company, Inc. December 12, 1977.
15. Kavalier, A. R., ed., Chemical Marketing Reporter, Vol. 214, No. 12, New York, New York, Schnell Publishing Company, Inc. September 18, 1978.

16. Kavalier, A. R., ed., Chemical Marketing Reporter, Vol. 215, No. 14, New York, New York, Schnell Publishing Company, Inc. April 2, 1979.
17. Kavalier, A. R., ed., Chemical Marketing Reporter, Vol. 215, No. 15, New York, New York, Schnell Publishing Company, Inc. April 9, 1979.
18. Kavalier, A. R., ed., Chemical Marketing Reporter, Vol. 215, No. 24, New York, New York, Schnell Publishing Company, Inc. June 4, 1979.
19. Kent, J. A., ed., Riegel's Handbook of Industrial Chemistry, 7th ed., New York, New York, Van Nostrand Rheinhold Company, 1974.
20. Kleburg, C., U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Personal Communication with B. B. Lee, Radian Corporation, April 1978.
21. Lowenheim, F. A., and M. K. Moran, revs., Faith Keyes, and Clark's Industrial Chemicals, New York, New York, John Wiley and Sons, Inc., 1975.
22. Mellan, Ibert, Industrial Solvents Handbook, 2nd ed. Park Ridge, New Jersey, Noyes Data Corporation, 1977.
23. National Paints and Coatings Association, Solvent Consumption Data, Washington, D.C., 1973.
24. Ostojic, N., End Uses of Solvents Containing Volatile Organic Compounds, Draft Final Report, Wethersfield, Connecticut, TRC-The Research Corporation of New England, December 1978.

25. Perry, Robert H., C. H. Chilton, and S. D. Kirkpatrick, Chemical Engineers' Handbook, New York, New York, McGraw Hill Book Company, 1969.
26. Sax, N. I., Dangerous Properties of Industrial Materials, 4th ed., New York, New York, Van Nostrand-Reinhold Company, 1975.
27. Shreve, R. N., and J. A. Brink, Jr., Chemical Process Industries, New York, New York, McGraw-Hill Book Company, 1977.
28. Stanford Research Institute, Chemical Economics Handbook, Menlo Park, California, various dates.
29. Stanford Research Institute, Data summaries prepared for the National Library of Medicine, Menlo Park, California, Various dates.
30. U.S. Environmental Protection Agency, "Chemical Use List," Fed. Reg., Vol. 43 (143), pp. 32222-32251 (1978).
31. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Control of Volatile Organic Emission from Existing Stationary Sources, Vol. II: Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles, and Light-Duty Trucks, EPA 450/2-77-008, Research Triangle Park, North Carolina, May 1977.

32. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Control of Volatile Organic Emissions from Existing Stationary Sources, Volume IV: Surface Coating of Magnet Wire, EPA 450/2-77-033, Research Triangle Park, North Carolina, December 1977.
33. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Control of Volatile Organic Emissions from Existing Sources, Volume VII: Factory Surface Coating of Flat Wood Paneling, EPA 450/2-78-032, Research Triangle Park, North Carolina, June 1978.
34. U.S. Environmental Protection Agency, Office of Research and Development. Industrial Process Profiles for Environmental Use, Chapter 10: Plastics and Resins, EPA 600/2-77-023j, Washington, D.C., January 1977.
35. U.S. Environmental Protection Agency, Office of Research and Development. Use of Organic Solvents in Textile Sizing and Desizing, EPA 600/2-77-126, Research Triangle Park, North Carolina, July 1977.
36. U.S. Environmental Protection Agency, Office of Toxic Substances. A Study of Industrial Data on Candidate Chemicals for Testing, EPA 560/5-77-006, Washington, D.C., August 1977.
37. United States International Trade Commission, Synthetic Organic Chemicals: United States Production and Sales, 1977, Washington, D.C., 1978.

38. U.S. National Institute for Occupational Safety and Health, Current Intelligence Bulletin 20, Tetrachloroethylene, U.S. Government Printing Office, Washington, D.C., 1978.
39. Verschuere, K., Handbook of Environmental Data on Organic Chemicals, New York, New York, Van Nostrand Reinhold Company, 1977.
40. Wilkins, G. E., et al., The Revised Organic Chemical Producers Data Base: Final Interim Report, EPA Contract No. 68-03-2623, Austin, Texas, Radian Corporation, March 1979.
41. Windholz, M., ed., The Merck Index, 9th ed., Rahway, New Jersey, Merck and Company, Inc., March 1977.
42. Weast, Robert C. and Samuel M. Selby, eds. Handbook of Chemistry and Physics, 47th edition. Cleveland, Ohio, The Chemical Rubber Company, 1966-1967.

APPENDIX A
DESIGN AND APPLICATION OF EPA EXPOSURE INDEX

DESIGN & APPLICATION OF EPA EXPOSURE INDEX

Auerbach Associates, Inc. (AAI) is designing an Index of Exposure for the purpose of assisting EPA in setting priorities for chemicals under the Toxic Substances Control Act. The Index of Exposure will serve to indicate the relative potential for exposure associated with a given use of a chemical.

The Index of Exposure proposed by AAI at once minimizes subjectivity and maximizes specificity and flexibility. In the following discussion, we will describe the design of the Index and its application to classifying and ranking chemical uses, as well as cases requiring special handling. The Appendix illustrates the manner in which the Index has been used to classify ten sample uses.

1. DESIGN OF EXPOSURE INDEX

The Exposure Index consists of two integrated elements: (1) the categories of exposure; and (2) the scoring system applied to the categories of exposure. The combination of these two elements comprises the Index of Exposure, as illustrated in Figure 1 and described in detail below.

1.1 Categories of Exposure

The Index of Exposure indicates the potential for both human and environmental exposure during a given use of a chemical. Both human and environmental exposures are characterized by a composite of "mode" and "amount" of exposure, yielding a classification into four major categories, or factors:

- Factor 1: Mode of Human Exposure
- Factor 2: Mode of Environmental Exposure
- Factor 3: Amount of Human Exposure
- Factor 4: Amount of Environmental Exposure

Factors 1 and 3, characterizing human exposure, are further divided into subcategories of exposure. An explanation of each factor and subfactor,

Factor 1 Mode of Human Exposure	Factor 2 Mode of Environmental Exposure	Factor 3 Amount of Human Exposure	Factor 4 Amount of Environmental Exposure
A. <u>Route of Exposure</u> 0 No exposure 1 Oral, topical or inhalation exposure 2 Any two of the above 3 All of the above B. <u>Form of Exposure</u> 0 Not applicable 1 Liquid*, solid or gaseous** 2 Any two of the above 3 All of the above	0 No exposure 1 Exposure via air, water or soil 2 Exposure via any two of the above 3 Exposure via all of the above	A. <u>Number of People Exposed</u> 0 < 200,000 1 200,000 - 2,000,000 2 2,000,000 - 20,000,000 3 > 20,000,000 B. <u>Frequency of Exposure</u> 0 Yearly or less frequently 1 Monthly 2 Weekly 3 Daily or continuously C. <u>Extent of Contact</u> 0 Trace contact 1 Light contact 2 Moderate contact 3 Heavy contact D. <u>Duration of Exposure</u> 0 Fleeting exposure 1 Short exposure 2 Medium exposure 3 Long exposure	0 No exposure, or exposure as constituent of a bulk solid 1 Up to 1% of substance 2 1 - 10% of substance 3 10 - 100% of substance

* Includes suspensions and solutions

** Includes gases, vapors, mists, aerosols and respirable size particulates

in the context of the Exposure Index, is presented in Table 1. Note that factors are defined in terms of the normal, or intended, use of a chemical. Exposures resulting from accidents are not considered, because accidents cannot be foreseen in any way which would permit reliable classification of exposure.

Furthermore, we did not attempt to place value judgments on the relative risk of the various modes of human and environmental exposures. For example, we considered oral, topical and inhalation exposure to represent equivalent exposure potentials. Thus, any two of these routes of exposure in combination would represent twice the exposure potential of a single route, and all three routes in combination would represent three times the exposure potential.

We chose this approach because we felt that without knowing the particular chemical being used, we could not determine whether one route or form of exposure posed an inherently greater exposure potential than any other route or form.

1.2 Scoring System for Index of Exposure

As illustrated in Figure 1, each variable within an exposure category has been assigned a numerical value. The values assigned are based on the relative degree of exposure associated with a given variable. The judgment of relative degree of exposure is subjective, but once each variable has been assigned a numerical value, the relative exposure scores are objectively established for any combination of variables.

In assigning a use to the exposure classification, the use would be given the numerical value of the variable(s) within each factor which best characterizes the potential for exposure associated with that use. The individual values would then be scored according to the following formula*:

$$r_j = \sum_{i=1}^8 w_i \cdot \frac{s_{ij}}{m_i} ,$$

*This formula was employed by Clement Associates in scoring chemicals for the TSCA Interagency Testing Committee.

TABLE 1. DEFINITIONS OF INDEX OF EXPOSURE FACTORS

Factor	Definition
Mode of Human Exposure	Means by which humans may be exposed during normal use of a substance*, expressed as a cumulation of two subfactors
Route of Exposure	Point of human contact with a substance during normal use
Form of Exposure	Physical state of the product being used
Mode of Environmental Exposure	Route by which a substance is released to the environment during normal use
Amount of Human Exposure	Amount of human exposure expressed as a cumulation of four subfactors
Number of People Exposed	Number of people who would come into contact with a substance during normal use. Categories were chosen to reflect percentage of U.S. population, such that: 200,000 = 0.1% 2,000,000 = 1% 20,000,000 = 10%
Frequency of Exposure	Frequency with which those people exposed to a substance would come into contact with it during normal use
Extent of Contact	Amount of substance to which a person would be exposed during normal use. This subfactor may be expressed as the percentage composition of the functional chemical in the product or as the percentage concentration of the functional chemical in the immediate area of use • Trace contact - Substance occurs only incidentally in the finished product (e.g., a polymerization intermediate which may exist only as an impurity in a textile fiber), or is present in the workplace in trace amounts as a result of incidental losses during processing in totally enclosed operations. • Light contact - Finished product contains up to 1% by weight of the substance, or the substance is present in the workplace as a result of incidental losses from batch operations.

TABLE 1. (continued)

Factor	Definition
3D. Duration of Exposure	• Moderate contact - Finished product contains 1-10% by weight of the substance. Occupational exposures are most likely to be light or heavy, rather than moderate, since industrial operations are largely either automatic, in which case the exposure is light, or manual, in which case the exposure is heavy. • Heavy contact - Finished product contains 10-100% by weight of the substance, substance is present in the workplace as a result of such operations as spray painting and paint spraying, or the substance is contacted by direct handling, as in unloading bags and drums or weighing in open containers. Length of time for which a person would be in contact with a substance during normal use: • Fleeting exposure - exposure of up to 1 second duration • Short exposure - exposure of 1 second to 1 minute • Medium exposure - exposure of 1 minute to 1 hour • Long exposure - exposure of longer than 1 hour duration
4. Amount of Environmental Exposure	Extent of environmental exposure in terms of the approximate amount of substance which enters the environment during normal use. For example, up to 100% of an aerosol spray might enter the environment, while less than 1% of an automotive fuel might enter the environment in its original form without undergoing combustion.

* As used here, the term "substance" does not refer to a particular chemical compound, but to any class of compounds providing a given function (e.g., propellant, tackifier, extender).

where w_i is the weight assigned to the i th factor group,

s_{ij} is the actual numerical value of the exposure variable assigned to the j th chemical use,

m_i is the maximum numerical value obtainable for that exposure variable, and

r_j is the score of the j th chemical use, from which its rank will be derived.

Note that although there are only four major factors, two of these have more than one subfactor, giving a total possible value of 8 for i in the above equation, if each of the subfactors is considered independently. If the subfactors are not considered separately, the value of i would be 4. For the examples considered herein, we have used $i=4$, so that each of the four major factors will carry equal weight. In this case, the weight of each subfactor in Factors 1 and 3 will be a fraction of the total weight of the factor.

This method of scoring allows each use assigned to the classification to be characterized by a specific combination of variables, allowing for a tremendous number of permutations.

After all chemical uses have been scored according to the method described above, a rank order of exposure potentials can be determined by listing each use in order of its numerical score.

1.2.1 Weighting

In the basic ranking of exposure potentials, each factor scored is assumed to be of equal importance, and thus all factors bear equal weight. In this case, the value of w_i in the scoring formula equals 1. However, by increasing the value of w_i for any given factor, that factor can be emphasized in calculating the rank of a chemical use. Any chemical uses which are characterized by a variable (other than zero) within the given factor will, when weighted, assume a higher rank relative to other chemical uses not characterized by that variable. For example, through weighting, either human

or environmental exposure categories can be made to appear at a higher rank than the other. Thus, these major factors can be examined independently of each other without having to use two separate classifications.

Note that the suggested arrangement of the Exposure Index, in which two factors are divided into subfactors, is inherently weighted to some extent. If all four major factors are considered to be equal in importance, the subfactors bear only a fraction of the total weight of the parent factor. Thus, the subfactor, "Number of People Exposed" bears one-quarter of the weight of the entire factor, "Amount of Human Exposure".

In taking this approach, we have assumed that EPA regards each of the four major factors as being of equal importance. However, by treating each subfactor as an independent unit, creating, in effect, eight factors, the inherent weighting can be eliminated. The result of the latter approach will be to place greater emphasis on the "Mode of Human Exposure" and the "Amount of Human Exposure", since these factors will be represented by more than one subfactor.

Use of the four-factor approach will result in a possible maximum of 49 rank levels, while use of the eight-factor approach will result in a possible maximum of 25 rank levels. In the latter case, the number of rank levels falls sufficiently close to EPA's suggested range of approximately 20 rank levels not to require any further adjustment. In the former case, the 49 possible rank levels could easily be consolidated into 24 or 25 rank levels.

2. APPLICATION OF EXPOSURE INDEX TO SCORING OF CHEMICAL USES

The scoring of ten sample uses is illustrated in Tables 2 and 3. The individual factor scores calculated by using the formula, $w_i \cdot \frac{s_{ij}}{m_i}$, are shown, and these scores are summed in the far right column. Table 2 gives the scores for occupational exposure and Table 3 gives the score for consumer exposure.

Uses*	Factors	1A $m_1 = 6$	1B $m_1 = 6$	2 $m_2 = 3$	3A $m_3 = 12$	3B $m_3 = 12$	3C $m_3 = 12$	3D $m_3 = 12$	4 $m_4 = 3$	Σ
No. 0032-070. uv absorbents for miscellaneous fabricated plastic products		1/6	1/6	1/3	1/12	3/12	1/12	3/12	1/3	1.667
No. 004-214. Accelerators for synthetic rubber		2/6	1/6	2/3	0/12	3/12	2/12	2/12	1/3	2.084
No. 014-0402. Aerosol propellants for disinfecting and exterminating		1/6	1/6	1/3	0/12	3/12	1/12	3/12	1/3	1.583
No. 015-04005. Algicides for swimming pool cleaning and maintenance		1/6	1/6	2/3	0/12	3/12	3/12	3/12	1/3	2.084
No. 015-0407. Algicides for sewerage treatment		1/6	2/6	1/3	0/12	3/12	2/12	3/12	2/3	2.167
No. 015-195. Algicides for pulp mill products		1/6	1/6	1/3	0/12	3/12	1/12	3/12	2/3	2.001
No. 049-283. Antifreezes for motor vehicles and equipment		1/6	1/6	1/3	0/12	3/12	2/12	3/12	1/3	1.667
No. 119-213. Chain stoppers for plastic materials and resins		1/6	2/6	1/3	0/12	3/12	2/12	2/12	1/3	1.750
No. 1211-021. Chemical intermediates for industrial organic chemicals		2/6	3/6	3/3	0/12	3/12	3/12	3/12	2/3	3.250
No. 173-2510. Detergent builders for detergents, soaps and disinfectants		2/6	2/6	3/3	0/12	3/12	2/12	3/12	1/3	2.666

*Numbers for uses come from the EPA Chemical Use Classification System.

TABLE 3. SCORES OF CHEMICAL USES FOR CONSUMER EXPOSURE

(Score = s_{ij}/m_i)

Uses*	Factors	1A $m_1 = 6$	1B $m_1 = 6$	2 $m_2 = 3$	3A $m_3 = 12$	3B $m_3 = 12$	3C $m_3 = 12$	3D $m_3 = 12$	4 $m_4 = 3$	Σ
No. 0032-070. uv absorbents for miscellaneous fabricated plastic products		2/6	1/6	2/3	3/12	2/12	1/12	2/12	1/3	2.167
No. 004-214. Accelerators for synthetic rubber		1/6	1/6	1/3	3/12	3/12	2/12	2/12	2/3	2.167
No. 014-0402. Aerosol propellants for disinfecting and exterminating		1/6	1/6	1/3	3/12	2/12	3/12	1/12	3/3	2.417
No. 015-04005. Algicides for swimming pool cleaning and maintenance		2/6	1/6	2/3	3/12	2/12	2/12	3/12	1/3	2.334
No. 015-0407. Algicides for sewerage treatment		0/6	0/6	1/3	0/12	0/12	0/12	0/12	2/3	1.000
No. 015-195. Algicides for pulp mill products		1/6	1/6	1/3	3/12	3/12	0/12	2/12	0/3	1.334
No. 049-283. Antifreezes for motor vehicles and equipment		1/6	1/6	2/3	2/12	0/12	3/12	1/12	3/3	2.501
No. 119-213. Chain stoppers for plastic materials and resins		1/6	1/6	1/3	3/12	2/12	1/12	2/12	0/3	1.334
No. 1211-021. Chemical intermediates for industrial organic chemicals		0/6	0/6	0/3	0/12	0/12	0/12	0/12	0/3	0.000
No. 173-2510. Detergent builders for detergents, soaps and disinfectants		2/6	2/6	1/3	3/12	3/12	3/12	2/12	3/3	2.916

Table 4 shows the basic rank order for all ten sample uses scored for consumer exposure (i.e., $w_1=1$). Table 5 (Effects of Weighting) shows how the basic rank order could change when one of the four major factors, in this case Amount of Human Exposure, is weighted. For the purpose of this illustration, $w_3=4$. (For a discussion of weighting, refer to Section 1.2.1.)

The Appendix presents the reasons for selecting particular exposure variables for each of the ten sample uses.

3. SPECIAL CASES

In applying the Index of Exposure to a selection of sample chemical uses, we found that two types of situations might arise which will require special handling. These situations, and our methods for dealing with them, are discussed below.

3.1 Incomplete Scoring Situations

Although this problem did not arise in the course of sample use scoring, it is quite possible that cases will occur in which we will be unable to assign a score to a chemical use for all of the categories in the Exposure Index. Leaving a category without a score would imply that the use in question involved no exposure in that category. This is an assumption which is not necessarily true and which would yield a lower score for that use than the score would have been, had the category in question been scored. Therefore, we have devised a method for completing the category with an approximate score value.

In deriving an approximate value, we will assume that the low exposure and high exposure values for any category of exposure will be easily determined for a given use, and that most of the uses for which an exposure is unknown will fall into the mid-range of values. Since it has been previously demonstrated that the possible exposure scores will follow a normal bell-shaped distribution (AAI letter of October 31, 1977), the above assumption is appropriate. Therefore, for any unknown score, we will assign the median numerical value and multiply this by whatever weight value is being used for

TABLE 4. BASIC RANK ORDER OF CONSUMER USES ($w_i = 1$)

<u>Rank</u>	<u>Score</u>	<u>Use</u>
1	2.916	Detergent builders for detergents, soaps and disinfectants
2	2.501	Antifreezes for motor vehicles and equipment
3	2.417	Aerosol propellants for disinfecting and exterminating
4	2.334	Algicides for swimming pool cleaning and maintenance
5	2.167	Accelerators for synthetic rubber
5	2.167	uv absorbents for miscellaneous fabricated plastic products
6	1.334	Algicides for pulp mill products
6	1.334	Chain stoppers for plastic materials and resins
7	1.000	Algicides for sewerage treatment
8	0.000	Chemical intermediates for industrial organic chemicals

TABLE 5. EFFECTS OF WEIGHTING
(Weighted Rank Order of Consumer Uses
($w_3 = 4$))

<u>Weighted Rank</u>	<u>(Unweighted Rank)</u>	<u>Weighted Score</u>	<u>(Unweighted Score)</u>	<u>Use</u>
1	(1)	5.667	(2.916)	Detergent builders for detergents, soaps and disinfectants
2	(4)	4.836	(2.334)	Algicides for swimming pool cleaning and maintenance
3	(5)	4.670	(2.167)	Accelerators for synthetic rubber
4	(3)	4.667	(2.417)	Aerosol propellants for disinfecting and exterminating
5	(5)	4.168	(2.167)	uv absorbents for miscellaneous fabricated plastic products
6	(2)	4.001	(2.501)	Antifreezes for motor vehicles and equipment
7	(6)	3.335	(1.334)	Algicides for pulp mill products
7	(6)	3.335	(1.334)	Chain stoppers for plastic materials and resins
8	(7)	1.000	(1.000)	Algicides for sewerage treatment
9	(8)	0.000	(0.000)	Chemical intermediates for industrial organic chemicals

TABLE 5. EFFECTS OF WEIGHTING
(Weighted Rank Order of Consumer Uses
($w_3 = 4$))

<u>Weighted Rank</u>	<u>(Unweighted Rank)</u>	<u>Weighted Score</u>	<u>(Unweighted Score)</u>	<u>Use</u>
1	(1)	5.667	(2.916)	Detergent builders for detergents, soaps and disinfectants
2	(4)	4.836	(2.334)	Algicides for swimming pool cleaning and maintenance
3	(5)	4.670	(2.167)	Accelerators for synthetic rubber
4	(3)	4.667	(2.417)	Aerosol propellants for disinfecting and exterminating
5	(5)	4.168	(2.167)	uv absorbents for miscellaneous fabricated plastic products
6	(2)	4.001	(2.501)	Antifreezes for motor vehicles and equipment
7	(6)	3.335	(1.334)	Algicides for pulp mill products
7	(6)	3.335	(1.334)	Chain stoppers for plastic materials and resins
8	(7)	1.000	(1.000)	Algicides for sewerage treatment
9	(8)	0.000	(0.000)	Chemical intermediates for industrial organic chemicals

the exposure category to determine the score. In a numerical range of 0 to 3, the median value would be 1.5.

This technique for data substitution is similar to the standard statistical technique of substituting an average value or a probable value for a missing data point in a series. The averaging technique is predicated on the use of a random sample population. Since the universe of chemical uses does not represent a random sample, we have modified this technique accordingly.

3.2 Single Use Comprising Multiple Industrial Processes

In one of the sample uses scored, we found that more than one industrial process could be involved, resulting in different occupational exposure scores. In this instance, ultraviolet (uv) absorbents for miscellaneous fabricated plastic products could be (1) incorporated into the plastic during fabrication (i.e., molding or extrusion); or (2) incorporated into a solution applied as a coating to the fabricated plastic product.

These are three possible methods for handling such situations:

- (1) Consider each industrial process as a separate use.
- (2) Consider each industrial process as a component of a single use and score each component separately, yielding multiple scores for a single use.
- (3) Follow method (2) above, then average the scores to yield a single score.

We recommend using method (1) to the extent feasible. For example, the case cited above would be separated into the following two uses:

- uv absorbents for miscellaneous fabricated plastic products
- uv absorbents for coatings

We have used this procedure in the present example. (See Appendix)

When this approach proves unfeasible, we recommend using method (2). We do not recommend averaging multiple scores for a single use, because of the distortion which could be introduced into the score. Averaging is based on the assumption that each industrial process scored is of equal importance, and such might very well not be the case.

4. CONCLUSION

In the foregoing discussion and in the Appendix, we have demonstrated that the EPA Index of Exposure proposed by AAI not only achieves its intended purpose, but that it has three significant advantages:

- (1) It minimizes subjectivity through the numerical scoring system.
- (2) It maximizes specificity by allowing rank levels to be determined on the basis of actual, specific exposures, rather than requiring exposure potentials to be fitted into predetermined rank levels.
- (3) It maximizes flexibility by permitting variable weighting of each exposure category.

APPENDIX B
EXPOSURE INDEX SCORES

Factor	Occupational Exposure Manufacture	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2 /6		/6
1B Form of Exposure	Liquid and gaseous	2 /6		/6
2 Mode of Environ. Exposure	Air, water	2 /3		/3
3A Number of People Exp.	<200,000	0 /12		/12
3B Frequency of Exposure	Daily	3 /12		/12
3C Extent of Contact	Light	1 /12		/12
3D Duration of Exposure	Long	3 /12		/12
4 Amount of Environ. Exposure	10-100%	3 /3		/3

3.08

CHEMICAL USE: Solvents for adhesives
(No. 352-1009)

680
C-247

Adhesives are used frequently in the office by secretaries and commercial and non-commercial artists and occasionally by consumers in the home and children in school.

180

Factor	Mfr. of adhesives	Occupational Exposure	S/H Value	Consumer Exposure	S/H Value
1A Route of Exposure	Inhalation and topical		2/6	Inhalation and topical	2/6
1B Form of Exposure	Liquid and gaseous (vapors)		2/6	Liquid and gaseous (vapors)	2/6
2 Body of Exposure	Air		1/3	Air	1/3
3A Number of People Exp.	< 200,000		0/12	> 20,000,000	3/12
3B Frequency of Exposure	Daily		3/12	Monthly	1/12
3C Extent of Contact	Heavy		3/12	Heavy	3/12
3D Duration of Exposure	Long		3/12	Medium	2/12
4 Amount of Exposure	Up to 1Z		1/3	Up to 1Z	1/3

CHEMICAL USE: Solvents for adhesives (Cont'd)
(No. 352-1009)

680
C-247

181

Factor	Office use	Occupational Exposure	S/H Value	Consumer Exposure	S/H Value
1A Route of Exposure		Inhalation and topical	2/6		/6
1B Form of Exposure		Liquid and gaseous (vapors)	2/6		/6
2 Mode of Environ. Exposure		Air	1/3		/3
3A Number of People Exp.		200,000 - 2,000,000	1/12		/12
3B Frequency of Exposure		Daily	3/12		/12
3C Extent of Contact		Heavy	3/12		/12
3D Duration of Exposure		Medium	2/12		/12
4 Amount of Environ. Exposure		Up to 12	1/3		/3
			2.07		

CHEMICAL USE: Solvents for Chemicals (No. 352-02)

Solvents used in the manufacture of chemicals are removed from the finished chemical. There is no consumer exposure.

162

Factor	Occupational Exposure	S/H Value	Consumer Exposure N.A.	S/H Value
1A Route of Exposure	Topical and Inhalation	2/6		/6
1B Form of Exposure	Liquid and Gaseous (vapors)	2/6		/6
2 Mode of Environ. Exposure	Air and Water	2/3		/3
3A Number of People Exp.	< 200,000	0/12		/12
3B Frequency of Exposure	Daily	3/12		/12
3C Extent of Contact	Light (enclosed operations)	1/12		/12
3D Duration of Exposure	Long	3/12		/12
4 Amount of Environ. Exposure	Up to 12	1/3		/3

CHEMICAL USE: Solvents for Research and Development
(No. 352-0406)

Exposure to solvents in this application would occur in chemical research laboratories and pilot plants. The only consumer exposure would occur among college and university students during chemistry coursework.

183

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Inhalation and Topical	2 / 6	Inhalation and Topical	2 / 6
1B Form of Exposure	Gaseous (vapors) and liquid	2 / 6	Gaseous (vapors) and liquid	2 / 6
2 Mode of Environ. Exposure	Air and Water	2 / 3	Air and Water	2 / 3
3A Number of People Exp.	< 200,000	0 / 12	< 200,000	0 / 12
3B Frequency of Exposure	Daily	3 / 12	Weekly	2 / 12
3C Extent of Contact	Heavy	3 / 12	Heavy	3 / 12
3D Duration of Exposure	Long	3 / 12	Medium	2 / 12
4 Amount of Environ. Exposure	1-10%	2 / 3	10-100%	3 / 3
				2.92
				2.75

CHEMICAL USE: Solvents for Laundry and Drycleaning
(No. 352-0412)

In most drycleaning plants, solvents are generally handled by circulation with pumps. However, the operator can contact solvent directly in charging the system, handling the solvent-laden clothes prior to drying and handling solvent-laden charcoal and filter papers. The consumer in coin operated laundries can contact the solvent as a trace residue in the dried clothes.

184

Factor	Occupational Exposure	S/M Value	Consumer Exposure In coin operated laundries	S/M Value
1A Route of Exposure	Inhalation and Topical	2/6	Inhalation and Topical	2/6
1B Form of Exposure	Liquid and Gaseous (vapors)	2/6	Solid and Gaseous (vapors)	2/6
2 Mode of Environ. Exposure	Air	1/3	Air	1/3
3A Number of People Exp.	< 200,000	0/12	2,000,000-20,000,000	2/12
3B Frequency of Exposure	Daily	3/12	Monthly	1/12
3C Extent of Contact	Heavy	3/12	Light	1/12
3D Duration of Exposure	Long	3/12	Medium	2/12
4 Amount of Environ. Exposure	1-10%	2/3	1-10%	2/3

CHEMICAL USE: Solvents for Repair Work (No. 352-042)

Solvents are used in repair work to clean metal parts, to remove paints and other coatings and to remove oils and grease from parts to be electroplated. Consumers doing repair work around the home might also come into contact with solvents.

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and Inhalation	2 / 6	Topical and Inhalation	2 / 6
1B Form of Exposure	Liquid and Gaseous (vapors)	2 / 6	Liquid and Gaseous (vapors)	2 / 6
2 Mode of Environ. Exposure	Water and Air	2 / 3	Water and Air	2 / 3
3A Number of People Exp.	200,000-2,000,000	1 / 12	2,000,000-20,000,000	2 / 12
3B Frequency of Exposure	Daily	3 / 12	Monthly	1 / 12
3C Extent of Contact	Heavy	3 / 12	Heavy	3 / 12
3D Duration of Exposure	Long	3 / 12	Long	3 / 12
4 Amount of Environ. Exposure	10-100%	3 / 3	10-100%	3 / 3
		3.16		3.08

CHEMICAL USE: Solvents for Furniture Repair and Refinishing
(No. 352-0421)

Solvents are used to strip old paint and as diluents for wood glues (adhesives).

Factor	Occupational Exposure	S/M Value	Consumer Exposure (Hobby)	S/M Value
1A Route of Exposure	Topical and Inhalation	2 /6	Topical and Inhalation	2 /6
1B Form of Exposure	Liquid and Gaseous (vapors)	2 /6	Liquid and Gaseous (vapors)	2 /6
2 Mode of Environ. Exposure	Water and Air	2 /3	Water and Air	2 /3
3A Number of People Exp.	<200,000	0 /12	200,000-2,000,000	1 /12
3B Frequency of Exposure	Daily	3 /12	Weekly	2 /12
3C Extent of Contact	Heavy	3 /12	Heavy	3 /12
3D Duration of Exposure	Long	3 /12	Long	3 /12
4 Amount of Environ. Exposure	10-100%	3 /3	10-100%	3 /3

CHEMICAL USE: Solvents for Surface Cleaning and Conditioning
(No. 352-0645)

Solvents are often used as degreasers to remove oil, waxes and coatings from metal surfaces prior to fabrication and/or coating. There is no consumer exposure to solvents used for this purpose.

Factor	Occupational Exposure	S/M Value	Consumer Exposure N.A.	S/M Value
1A Route of Exposure	Topical and Inhalation	2 / 6		/ 6
1B Form of Exposure	Liquid and Gaseous (vapors)	2 / 6		/ 6
2 Mode of Environ. Exposure	Air and Water	2 / 3		/ 3
3A Number of People Exp.	200,000-2,000,000	1 / 12		/ 12
3B Frequency of Exposure	Daily	3 / 12		/ 12
3C Extent of Contact	Heavy	3 / 12		/ 12
3D Duration of Exposure	Long	3 / 12		/ 12
4 Amount of Environ. Exposure	1-10%	2 / 3		/ 3

2.83

CHEMICAL USE: Solvents for Fabricated Rubber and Plastic Products (No. 352-07)

The use of solvents in the manufacture of fabricated rubber and plastic products is not extensive. Except for tire retreading, solvent use in this sector is small.

Factor	Occupational Exposure	S/H Value	Consumer Exposure N.A.	S/H Value
1A Route of Exposure	Topical and Inhalation	2 /6		/6
1B Form of Exposure	Liquid and Gaseous (vapors)	2 /6		/6
2 Mode of Environ. Exposure	Air and Water	2 /3		/3
3A Number of People Exp.	< 200,000	0 /12		/12
3B Frequency of Exposure	Daily	3 /12		/12
3C Extent of Contact	Heavy	3 /12		/12
3D Duration of Exposure	Medium	2 /12		/12
4 Amount of Environ. Exposure	10-100%	3 /3		/3

CHEMICAL USE: Solvents for Oil and Gas Extraction
(No. 352-154)

Solvents are used to extract certain constituents from natural gases at or near the well head. Such operations are continuous in enclosed equipment, with little or no loss to the environment.

Factor	Occupational Exposure	S/H Value	Consumer Exposure N.A.	S/H Value
1A Route of Exposure	Topical and Inhalation	2 /6		
1B Form of Exposure	Liquid and Gaseous (vapors)	2 /6		/6
2 Mode of Environ. Exposure	Air	1 /3		/6
3A Number of People Exp.	< 200,000	0 /12		/3
3B Frequency of Exposure	Daily	3 /12		/12
3C Extent of Contact	Trace (totally enclosed operation)	0 /12		/12
3D Duration of Exposure	Long	3 /12		/12
4 Amount of Environ. Exposure	Up to 12	1 /3		/12
				/3

CHEMICAL USE: Solvents for Paint and Allied Products
(No. 352-18)

Occupational use of solvents in paint and allied products occurs both in the manufacture of these products and in their use by professional painters. Consumer exposure occurs from the use of these products by the homeowner.

190

Factor	Occupational Exposure Manufacture of paints	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and Inhalation	2 / 6	Topical and Inhalation	2 / 6
1B Form of Exposure	Liquid and Gaseous (vapors)	2 / 6	Liquid and Gaseous (vapors)	2 / 6
2 Mode of Exposure	Air	1 / 3	Air and Water	2 / 3
3A Number of People Exp.	< 200,000	0 / 12	> 20,000,000	3 / 12
3B Frequency of Exposure	Daily	3 / 12	Yearly	0 / 12
3C Extent of Contact	Light (enclosed batch operation)	1 / 12	Heavy	3 / 12
3D Duration of Exposure	Long	3 / 12	Long	3 / 12
4 Amount of Exposure	Up to 12	1 / 3	10-100%	3 / 3

CHEMICAL USE: Solvents for Paint and Allied Products (continued)
(No. 352-18)

191

Factor	Painters	Occupational Exposure	S/H Value	Consumer Exposure N. A.	S/H Value
1A Route of Exposure		Topical and Inhalation	2/6		/6
1B Form of Exposure		Liquid and Gaseous (vapors)	2/6		/6
2 Mode of Environ. Exposure	Air		1/3		/3
3A Number of People Exp.	200,000-2,000,000		1/12		/12
3B Frequency of Exposure	Daily		3/12		/12
3C Extent of Contact	Heavy		3/12		/12
3D Duration of Exposure	Long		3/12		/12
4 Amount of Environ. Exposure	10-100%		3/3		/3

2.82

CHEMICAL USE: Solvents for Petroleum Refining (No. 352-20)

Solvents are used to refine petroleum products in continuous processes.
There is no consumer exposure in this application.

Factor	Occupational Exposure	S/M Value	Consumer Exposure N.A.	S/M Value
1A Route of Exposure	Topical and Inhalation	2 /6		/6
1B Form of Exposure	Liquid and Gaseous (vapors)	2 /6		/6
2 Mode of Environ. Exposure	Air	1 /3		/3
3A Number of People Exp.	< 200,000	0 /12		/12
3B Frequency of Exposure	Daily	3 /12		/12
3C Extent of Contact	Trace	0 /12		/12
3D Duration of Exposure	Long	3 /12		/12
4 Amount of Environ. Exposure	Up to 1Z	1 /3		/3

CHEMICAL USE: Solvents for Plastic and Rubber Materials and Synthetics (not fabricated) (No. 352-21)

Solvents are used as reaction media and to clean equipment. In both cases, the solvents are recovered through recycling. Contaminated solvents that cannot be reclaimed may be incinerated. There is no consumer exposure.

193

Factor	Occupational Exposure	S/M Value	Consumer Exposure N.A.	S/M Value
1A Route of Exposure	Inhalation and Topical	2 /6		
1B Form of Exposure	Liquid and Gaseous (vapors)	2 /6		/6
2 Mode of Exposure	Air	1 /3		/6
3A Number of People Exp.	< 200,000	0 /12		/3
3B Frequency of Exposure	Daily	3 /12		/12
3C Extent of Contact	Light (Batch operations)	1 /12		/12
3D Duration of Exposure	Long	3 /12		/12
4 Amount of Environ. Exposure	Up to 12	1 /3		/12
				/3

1.90

CHEMICAL USE: Solvents for Printing Operations
(No. 352-231)

— Solvents exposure results from use of solvent-containing inks and solvents used for equipment cleaning. All exposure occurs in commercial print shops.

Factor	Occupational Exposure	S/M Value	Consumer Exposure N.A.	S/M Value
1A Route of Exposure	Topical and Inhalation	2 /6		/6
1B Form of Exposure	Liquid and Gaseous (vapors)	2 /6		/6
2 Mode of Environ. Exposure	Air	1 /3		/3
3A Number of People Exp.	200,000-2,000,000	1 /12		/12
3B Frequency of Exposure	Daily	3 /12		/12
3C Extent of Contact	Moderate	2 /12		/12
3D Duration of Exposure	Long	3 /12		/12
4 Amount of Environ. Exposure	10-100%	3 /3		/3

CHEMICAL USE: Solvents for Printing Inks (No. 352-24)

Solvents are used as vehicles in the manufacture of printing inks.

195

Factor	Occupational Exposure	S/M Value	Consumer Exposure N.A.	S/H Value
1A Route of Exposure	Topical and Inhalation	2/6		
1B Form of Exposure	Liquid and Gaseous (vapors)	2/6		/6
2 Mode of Environ. Exposure	Air	1/3		/6
3A Number of People Exp.	≤ 200,000			/3
3B Frequency of Exposure	Daily	0/12		/12
3C Extent of Contact	Light (Batch operations)	3/12		/12
3D Duration of Exposure	Long	1/12		/12
4 Amount of Environ. Exposure	Up to 12	3/12		/12
		1/3		/3
1.90				

CHEMICAL USE: Solvents for Polishes and Related Products
(No. 352-2511)

Solvents are used as vehicles in the manufacture of polishes and related cleaning products. Another occupational exposure to these solvents occurs during their use by janitorial personnel. Consumers are exposed during housecleaning.

Factor	Occupational Exposure Manufacture of polishes	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and Inhalation	2/6	Topical and Inhalation	2/6
1B Form of Exposure	Liquid and Gaseous (vapors)	2/6	Liquid or Solid and Gaseous (vapors)	2/6
2 Mode of Exposure	Air	1/3	Air and water (via washing of cleaning cloths)	2/3
3A Number of People Exp.	< 200,000	0/12	> 20,000,000	3/12
3B Frequency of Exposure	Daily	3/12	Weekly	2/12
3C Extent of Contact	Moderate (Batch operation)	2/12	Moderate	2/12
3D Duration of Exposure	Long	3/12	Medium	2/12
4 Amount of Exposure	Up to 1%	1/3	1-10%	2/3

CHEMICAL USE: Solvents for Polishes and Related Products (continued)
(No. 352-2511)

197

Factor	Occupational Exposure Janitorial Services	S/H Value	Consumer Exposure N.A.	S/H Value
1A Route of Exposure	Topical and Inhalation	2 /6		/6
1B Form of Exposure	Liquid or Solid and Gaseous (vapors)	2 /6		/6
2 Mode of Environ. Exposure	Air and Water (via washing of cleaning cloths)	2 /3		/3
3A Number of People Exp.	200,000-2,000,000	1 /12		/12
3B Frequency of Exposure	Daily	3 /12		/12
3C Extent of Contact	Heavy	3 /12		/12
3D Duration of Exposure	Long	3 /12		/12
4 Amount of Environ. Exposure	1-10%	2 /3		/3
		2.83		

Solvents for Manufacturing Dyes
(No. 352-11330)

Radian Derived

Factor	Occupational Exposure Mfg of dyes	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Inhalation and topical	2 /6		/6
1B Form of Exposure	Liquid and gaseous	2 /6		/6
2 Mode of Environ. Exposure	Air and water	2 /3		/3
3A Number of People Exp.	<200,000	0 /12		/12
3B Frequency of Exposure	Daily	3 /12		/12
3C Extent of Contact	Light	1 /12		/12
3D Duration of Exposure	Long	3 /12		/12
4 Amount of Environ. Exposure	Up to 1%	1 /3		/3

Solvents for Dyes for Plain Dyed
and Finished Fibers, Yarn and Fabrics
(No. 352-11330-2702)

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and Inhalation	2/6	Topical	1/6
1B Form of Exposure	Liquid and gaseous	2/6	Solid	1/6
2 Mode of Environ. Exposure	Air and water	2/3	Water	1/3
3A Number of People Exp.	<200,000	0/12	>20,000,000	3/12
3B Frequency of Exposure	Daily	3/12	Daily	3/12
3C Extent of Contact	Heavy	3/12	Trace	0/12
3D Duration of Exposure	Long	3/12	Long	3/12
4 Amount of Environ. Exposure	10-100%	3/3	As constituent of bulk solid	0/3

3.08

1.42

Solvents for Textile Processing
(352-1368)

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure				
1B Form of Exposure	Topical and inhalation	2/6		/6
2 Mode of Environ. Exposure	Liquid and gaseous	2/6		/6
3A Number of People Exp.	Air, water	2/3		/3
3B Frequency of Exposure	<200,000	0/12		/12
3C Extent of Contact	Daily	3/12		/12
3D Duration of Exposure	Light	1/12		/12
4 Amount of Environ. Exposure	Long	3/12		/12
	1-10	2/3		/3

CHEMICAL USE: Tar removers for cleaning and maintenance
(No. 366-0400)

These are usually solvents alone or solvents blended with water and detergents to form an emulsion. Consumer exposure is limited to an occasional use in the home. Occupational exposure is limited to maintenance and cleaning personnel.

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6	Topical and inhalation	2/6
1B Form of Exposure	Liquid and gaseous (vapors)	2/6	Liquid and gaseous (vapors)	2/6
2 Medium of Exposure	Water and air	2/3	Water and air	2/3
3A Number of People Exp.	200,000 - 2,000,000	1/12	> 20,000,000	3/12
3B Frequency of Exposure	Weekly	2/12	Yearly	0/12
3C Extent of Contact	Heavy	3/12	Heavy	3/12
3D Duration of Exposure	Medium	2/12	Medium	2/12
4 Amount of Environ. Exposure	10-100%	3/3	10-100%	3/3

3.00

3.00

CHEMICAL USE: Tar Removers for laundry and drycleaning
(No. 366-0412)

These are usually spotting agents used almost exclusively in professional laundries and drycleaning establishments. There is no consumer exposure.

Factor	Occupational Exposure	S/M Value	Consumer Exposure N.A.	S/M Value
1A Route of Exposure	Topical and inhalation	2/6		/6
1B Form of Exposure	Liquid and gaseous (vapors)	2/6		/6
2 Mode of Environ. Exposure	Water and air	2/3		/3
3A Number of People Exp.	200,000 - 2,000,000	1/12		/12
3B Frequency of Exposure	Daily	3/12		/12
3C Extent of Contact	Heavy	3/12		/12
3D Duration of Exposure	Long	3/12		/12
4 Amount of Environ. Exposure	10-100%	3/3		/3

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2 /6		/6
1B Form of Exposure	Liquid and gaseous	2 /6		/6
2 Mode of Environ. Exposure	Air, water	2 /3		/3
3A Number of People Exp.	<200,000	0 /12		/12
3B Frequency of Exposure	Daily	3 /12		/12
3C Extent of Contact	Heavy	3 /12		/12
3D Duration of Exposure	Long	3 /12		/12
4 Amount of Environ. Exposure	10-100%	3 /3		/3

3.08

Solvents for Leather and
Fur Tanning (No. 352-122)

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6		/6
1B Form of Exposure	Gaseous and liquid	2/6		/6
2 Mode of Environ. Exposure	Air and water	2/3		/3
3A Number of People Exp.	<200,000	0/12		/12
3B Frequency of Exposure	Daily	3/12		/12
3C Extent of Contact	Heavy	3/12		/12
3D Duration of Exposure	Long	3/12		/12
4 Amount of Environ. Exposure	10-100%	3/3		/3

3.08

Solvents for Drain Cleaners
(No. 352-25126)

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6	Topical and inhalation	2/6
1B Form of Exposure	Gaseous, liquid	2/6	Gaseous, liquid	2/6
2 Mode of Environ. Exposure	Air	1/3	Air, water	2/3
3A Number of People Exp.	<200,000	0/12	2,000,000 - 20,000,000	2/12
3B Frequency of Exposure	Daily	3/12	Monthly	1/12
3C Extent of Contact	Light	1/12	Heavy	3/12
3D Duration of Exposure	Long	3/12	Short	1/12
4 Amount of Environ. Exposure	0-1%	1/3	10-100%	3/3

1.90

2.91

Solvents for Manicuring Preparations
(No. 352-2504)

Radian Derived

Factor	Occupational Exposure Mfg.	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6	Topical and inhalation	2/6
1B Form of Exposure	Liquid and gaseous	2/6	Liquid and gaseous	2/6
2 Mode of Environ. Exposure	Air	1/3	Air	1/3
3A Number of People Exp.	<200,000	0/12	2,000,000 - 20,000,000	2/12
3B Frequency of Exposure	Daily	3/12	Daily	3/12
3C Extent of Contact	Light	1/12	Moderate	2/12
3D Duration of Exposure	Long	3/12	Short	1/12
4 Amount of Environ. Exposure	0-1%	0/3	10-100%	3/3

1.57

2.66

Solvents for Manicuring Preparations (Cont'd.)
(No. 352-2504)

Radian Derived

Factor	Occupational Exposure Manicurists	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and Inhalation	2/6		/6
1B Form of Exposure	Liquid and gaseous	2/6		/6
2 Mode of Environ. Exposure	Air	1/3		/3
3A Number of People Exp.	<200,000	0/12		/12
3B Frequency of Exposure	Daily	3/12		/12
3C Extent of Contact	Heavy	3/12		/12
3D Duration of Exposure	Long	3/12		/12
4 Amount of Environ. Exposure	10-100%	3/3		/3

2.74

Solvents for Fluorescent Lamps
(No. 352-14110)

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6		/6
1B Form of Exposure	Liquid and gaseous	2/6		/6
2 Mode of Environ. Exposure	Air	1/3		/3
3A Number of People Exp.	<200,000	0/12		/12
3B Frequency of Exposure	Daily	3/12		/12
3C Extent of Contact	Light	1/12		/12
3D Duration of Exposure	Long	3/12		/12
4 Amount of Environ. Exposure	0-1%	1/3		/3
1.90				

Solvents for Shoe Polishes
(No. 352-25115)

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6	Topical and inhalation	2/6
1B Form of Exposure	Liquid or gaseous	2/6	Liquid or gaseous	2/6
2 Mode of Environ. Exposure	Air	1/3	Air	1/3
3A Number of People Exp.	<200,000	0/12	200,000 - 20,000,000	2/12
3B Frequency of Exposure	Daily	3/12	Monthly	1/12
3C Extent of Contact	Light	1/12	Heavy	3/12
3D Duration of Exposure	Long	3/12	Short	1/12
4 Amount of Environ. Exposure	0-1%	1/3	10-100%	3/3

1.90

2.57

Solvents for Aerosol Personal Products
(No. 352-000C)

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6	Topical and inhalation	2/6
1B Form of Exposure	Gaseous, liquid	2/6	Gaseous	1/6
2 Mode of Environ. Exposure	Air, water	2/3	Air	1/3
3A Number of People Exp.	<200,000	0/12	720,000,000	3/12
3B Frequency of Exposure	Daily	3/12	Daily	3/12
3C Extent of Contact	Light	1/12	Moderate	2/12
3D Duration of Exposure	Long	3/12	Short	1/12
4 Amount of Environ. Exposure	0-1%	1/3	10-100%	3/3

2.24

2.58

Radian Derived

Factor	Occupational Exposure Mfg.	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6		/6
1B Form of Exposure	Liquid and gaseous	2/6		/6
2 Mode of Environ. Exposure	Air	1/3		/3
3A Number of People Exp.	<200,000	0/12		/12
3B Frequency of Exposure	Daily	3/12		/12
3C Extent of Contact	Light	1/12		/12
3D Duration of Exposure	Long	3/12		/12
4 Amount of Environ. Exposure	0-1%	1/3		/3

1.90

Solvents for Chemicals for
Brazing, Welding, and Soldering
(No. 352-12274-0640)

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Inhalation	1/6		/6
1B Form of Exposure	Gaseous	1/6		/6
2 Mode of Environ. Exposure	Air	1/3		/3
3A Number of People Exp.	200,000 - 2,000,000	2/12		/12
3B Frequency of Exposure	Daily	3/12		/12
3C Extent of Contact	Light	1/12		/12
3D Duration of Exposure	Long	3/12		/12
4 Amount of Environ. Exposure	0-1%	1/3		/3

1.75

Solvents for Spotting Agents
(No. 352-1309-04120)

Spotting agents are washed out in
the dry cleaning solvent.

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2 /6	Topical and inhalation	2 /6
1B Form of Exposure	Liquid or gaseous	2 /6	Liquid or gaseous	2 /6
2 Mode of Environ. Exposure	Air	1 /3	Air and water	2 /3
3A Number of People Exp.	<200,000	0 /12	200,000 - 20,000,000	2 /12
3B Frequency of Exposure	Daily	3 /12	Monthly	1 /12
3C Extent of Contact	Heavy	3 /12	Light	1 /12
3D Duration of Exposure	Long	3 /12	Short	1 /12
4 Amount of Environ. Exposure	10-100%	3 /3	10-100%	3 /3

2.74

2.74

Solvents for Specialty Lubricants
(No. 352-1271)

Radian Derived

Factor	Occupational Exposure Mfg.	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and Inhalation	2/6	Inhalation	1/6
1B Form of Exposure	Gaseous and Liquid	2/6	Gaseous	1/6
2 Mode of Environ. Exposure	Air	1/3	Air	1/3
3A Number of People Exp.	<200,000	0/12	<200,000	0/12
3B Frequency of Exposure	Daily	3/12	Daily	3/12
3C Extent of Contact	Light	1/12	Light	1/12
3D Duration of Exposure	Long	3/12	Long	3/12
4 Amount of Environ. Exposure	0-1%	1/3	10-100%	3/3

1.90

2.25

Solvents for Food
(No. 352-000a)

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6	Oral	1/6
1B Form of Exposure	Liquid and gaseous	2/6	Liquid and gaseous	2/6
2 Mode of Environ. Exposure	Water, air	2/3	Water	1/3
3A Number of People Exp.	<200,000	0/12	>20,000,000	3/12
3B Frequency of Exposure	Daily	3/12	Daily	3/12
3C Extent of Contact	Light	1/12	Trace	0/12
3D Duration of Exposure	Long	3/12	Medium	2/12
4 Amount of Environ. Exposure	1-10%	2/3	0	0/3

2.58

1.5

Solvents for Crop Production
(No. 352-012)

Radian Derived

Factor	Occupational Exposure Farmers	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6	Topical and inhalation	2/6
1B Form of Exposure	Liquid and gaseous	2/6	Liquid and gaseous	2/6
2 Mode of Environ. Exposure	Air, water, soil	3/3	Air, water, soil	3/3
3A Number of People Exp.	200,000 - 2,000,000	1/12	2,000,000 - 20,000,000	2/12
3B Frequency of Exposure	Monthly	1/12	Monthly	1/12
3C Extent of Contact	Heavy	3/12	Heavy	3/12
3D Duration of Exposure	Medium	2/12	Medium	2/12
4 Amount of Environ. Exposure	10-100%	3/3	10-100%	3/3

3.33

3.24

Radian Derived

Factor	Occupational Exposure Mfg.	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6		/6
1B Form of Exposure	Liquid and gaseous	2/6		/6
2 Mode of Environ. Exposure	Air and water	2/3		/3
3A Number of People Exp.	<200,000	0/12		/12
3B Frequency of Exposure	Daily	3/12		/12
3C Extent of Contact	Moderate	2/12		/12
3D Duration of Exposure	Long	3/12		/12
4 Amount of Environ. Exposure	1-10%	2/3		/3

2.67

Radian Derived

218

Radian Derived

Factor	Occupational Exposure Professional exterminators	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2 /6		/6
1B Form of Exposure	Gaseous	1 /6		/6
2 Mode of Environ. Exposure	Air, water, soil	3 /3		/3
3A Number of People Exp.	<200,000	0 /12		/12
3B Frequency of Exposure	Daily	3 /12		/12
3C Extent of Contact	Heavy	3 /12		/12
3D Duration of Exposure	Long	3 /12		/12
4 Amount of Environ. Exposure	10-100%	3 /3		/3

3.25

Solvents for Hydraulic Fluids
for Transportation Equipment
(No. 352-1252-28)

Radian Derived

Factor	Occupational Exposure Mechanical & Service Station Oprs.	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6	Topical and inhalation	2/6
1B Form of Exposure	Liquid and gaseous	2/6	Liquid and gaseous	2/6
2 Mode of Environ. Exposure	Air, water	2/3	Air	1/3
3A Number of People Exp.	200,000 - 2,000,000	1/12	2,000,000 - 20,000,000	2/12
3B Frequency of Exposure	Daily	3/12	Yearly	0/12
3C Extent of Contact	Heavy	3/12	Light	1/12
3D Duration of Exposure	Long	3/12	Short	1/12
4 Amount of Environ. Exposure	10-100%	3/3	10-100%	3/3

3.16

2.32

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6		/6
1B Form of Exposure	Gaseous	1/6		/6
2 Mode of Environ. Exposure	Air	1/3		/3
3A Number of People Exp.	<200,000	0/12		/12
3B Frequency of Exposure	Daily	3/12		/12
3C Extent of Contact	Moderate	2/12		/12
3D Duration of Exposure	Long	3/12		/12
4 Amount of Environ. Exposure	10-100%	3/3		/3

2.50

Solvents for Pharmaceuticals
(No. 352-000)

Solvents used in the manufacture of
drugs are removed from the finished
product.

Radian Derived

Factor	Occupational Exposure	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6	Oral, topical, inhalation	3/6
1B Form of Exposure	Liquid and gaseous	2/6	Liquid and gaseous	2/6
2 Mode of Environ. Exposure	Air and water	2/3	Water	1/3
3A Number of People Exp.	<200,000	0/12	>200,000,000	3/12
3B Frequency of Exposure	Daily	3/12	Monthly	1/12
3C Extent of Contact	Light	1/12	Trace	0/12
3D Duration of Exposure	Long	3/12	Medium	2/12
4 Amount of Environ. Exposure	1-10%	2/3	0	0/3

2.58

1.66

Solvents for Explosives
(No. 352-1206) or (No. 352-170)

Radian Derived

Factor	Occupational Exposure Manufacture	S/M Value	Consumer Exposure	S/M Value
1A Route of Exposure	Topical and inhalation	2/6		/6
1B Form of Exposure	Liquid and gaseous	2/6		/6
2 Mode of Environ. Exposure	Air, water	2/3		/3
3A Number of People Exp.	<200,000	0/12		/12
3B Frequency of Exposure	Daily	3/12		/12
3C Extent of Contact	Light	1/12		/12
3D Duration of Exposure	Long	3/12		/12
4 Amount of Environ. Exposure	10-100%	3/3		/3

2.91

APPENDIX C
RESULTS OF MANUAL PATENT SEARCH FOR
FIVE SOLVENTS

<u>Specific Solvent Use</u>	<u>Chemical Abstracts Reference No.</u>
<u>DIETHYLENE GLYCOL</u>	
Solvent in inks	82:126756n 84:75951d
Solvent in dyes	78:31733f 79:20127f 83:165710h 84:19002h 84:45931e
Solvent for hydrocarbon extraction	78:6179x 78:57995t 83:166583f 84:7289u 84:108138z 84:121400y
Solvent for terephthalic acid manufacture	79:18408e
Solvent in electroless plating of metal	80:51605k
Lubricating solvent in metal working	79:106637j
Solvent in brake fluids	84:92573z
Solvent for soldering & welding	84:154110g
Solvent for SO ₂ absorption	85:82644e
Solvent in preparing carbonless paper	85:144979d
Solvent for cleaning textiles	83:117632n
Solvent for surface cleaning machinery	82:17525r
Solvent in manufacturing leather substitutes	78:5110f

<u>Specific Solvent Use</u>	<u>Chemical Abstracts Reference No.</u>
<u>XYLENES</u>	
Solvent in polymer/plastics manufacturing	85:6814v 83:80891t 85:160986j 80:96570m 76:154463j 77:35866d 82:44675w 82:4882e
Solvent for paint stripping	78:17761g 81:39083b 80:97435h
Solvent in synthetic fiber production	85:7196g 81:92892r 81:92891q
Solvent in waterproofing, treating, and strengthening concrete	85:165697a 82:102454m 78:127995u
Solvent for stain removers from metal	76:129228d
Solvent for phosphor in fluorescent lamps	76:92932a
Deinking solvent	85:23061q
Solvent for soil binding and mulching compounds	81:12469v
Solvent for adhesives	84:18699d
Solvent for preparation of carbonless paper	84:52149j
Leather and textile cleaning solvent	84:46470r
Solvent for decal removal	84:91829a
Toluene diisocyanate solvent	84:90743f
Solvent for asphalt removal	83:13267f
Solvent in insulating foams	80:97523k

<u>Specific Solvent Use</u>	<u>Chemical Abstracts Reference No.</u>
<u>ACETONE</u>	
Solvent in plastics manufacturing	82:86858p 85:34256h 84:151920k
Petroleum extraction solvent	81:172816j 84:62283n
Solvent in dyes and dye application	78:112698a 77:127952g 77:127943e 82:112730n 85:64700r 85:79608r
Solvent in dry cleaning	82:100618u 81:137873d
Solvent in photographic solutions	79:151655z 85:151723u
Solvent for cleaning electronic parts	76:101332j 79:140865s
Nitrocellulose solvent	78:6088s 83:134498r
Solvent for coating & treating wood	80:16613q 85:7556z
Solvent for treating concrete	79:57212f
Solvent in de-acidifying natural gas	80:123016u
Solvent for non-cellulosic fibers	80:49214p 84:6372d
Solvent for carbonless paper	84:172135y
Solvent for coating wire	85:144865p
Solvent in coal liquefaction processes	85:163104f
Solvent in asphalt production	83:13269h
Solvent for protective metal coatings	83:83818k

<u>Specific Solvent Use</u>	<u>Chemical Abstracts Reference No.</u>
<u>ACETONE (Continued)</u>	
Solvents for removing oil from water	83:82488r
Solvent for removing dyes from leather goods	78:44967k
Solvent in wood pulping	77:50469v
Solvents in lubricants/degreasers	77:77605y
Solvent for removing rubber from metal	76:114486n
Solvent for oil seed extraction	78:126223d
<u>ETHYLENE GLYCOL MONOETHYL ETHER</u>	
Solvent in preparing photosensitive resins	85:200580f 85:102400c 84:67883t 79:151655z
Solvent for protective coatings (especially for metals)	85:125895q 78:102015m 76:36590a 83:46990q 83:107385v
Solvent for surface cleaning electronic components	78:91050r 80:122700a 84:157272x 85:64914p
Solvent for aerosol pesticides	83:127553b
Solvent for cleaning leather products	82:100109d
Solvent for stripping surface coatings	85:64917s
Solvent for petroleum extraction	84:92538s
Solvent for decolorizing plastics	83:116318c
Solvent in producing colorfast textiles	84:45937m
Solvent in fluorescent lamps	79:47051p
Solvent in paint strippers	85:162054c
Solvent in welding	81:125347x

<u>Specific Solvent Use</u>	<u>Chemical Abstracts Reference No.</u>
<u>ETHYLENE GLYCOL MONOBUTYL ETHER</u>	
Solvent for petroleum extraction (including drilling fluid solvent and solvent in tertiary oil re- covery)	82:161845e 76:61513k 78:166955e 82:61705y 82:127340j 84:92538s 84:46979p 84:46980g 80:50160z 80:61841y
Solvent for chemicals	85:78624f 85:108298x
Solvent for soldering and welding	78:75101c 79:117834x
Solvent for dyes	82:172611j 83:165711j 84:19062c
Solvent in fire extinguisher fluids and foams	79:33293g 79:33292f 79:147621t 85:162955x
Solvent in leather treating	80:49296s 83:149126s
Solvent for cleaning electronic circuit boards	81:107520u
Solvent for removal of oil from water	81:140651k
Solvent for photosensitive resins	84:128788q
Solvent for treating printing plates	83:35732f
Solvent in pharmaceutical manufacturing	83:152267u
Solvent for textile cleaners	83:149531v
Solvent in manufacturing capacitors	83:201074q
Solvent for waterproofing textiles	82:59842x
Solvent in electroless plating	78:59401v
Solvent in denture cleaning solutions	81:82263x

Miscellaneous Occupational Health and Safety References for
xylene, acetone, and ethylene glycol monoethyl ether:

ACETONE

83:168131f
83:160132g

ETHYLENE GLYCOL MONOETHYL ETHER

83:168131f
83:168132g
85:165888p

XYLENE

85:165865d
84:155038b
84:169006b
85:98639t
84:155059j
80:6563j
79:39061b
81:67999y
81:53876u
81:67995u
84:184380n